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INTRODUCTION

SCIENCE has its romantic as well as its practical side. Your manipulator of test tubes and retorts is as much an adventurer as any Cortez or Drake. He plunges into the unknown, never dreaming what the result of an investigation may be. The Crookes tube in the hands of Roentgen revealed the existence of X-rays—a manifestation that seemed romantically impossible when it was first discovered. The invention of a new instrument often means an immeasurable broadening of scientific achievement. The spectroscope not only refined chemical methods; it also changed the entire conception of the stars. The oil-immersion lens now applied to the microscope has given bacteriology and medicine a new significance.

It is the purpose of this volume to exhibit both the romantic and the practical aspects of science. The text and the illustrations have all been drawn from the Popular Science Monthly. The authors have willingly coöperated with the editor to make their interpretations of the phases of current science not only accurate, but simple enough to be understood by the technically untrained and, above all, imaginative enough to awaken a latent liking for the work which great engineers and inventors have done to make this the most dramatically interesting period in the whole history of the world.

While the individual writers have done their best to hold the readers' interest, they have not lost sight of the fact that it was their task to arouse a healthy interest in science. If there is a practical point to a new discovery or a new mechanical principle, they have pointed it out. Accordingly, the volume should prove of immense practical value in the hands of a reader who seeks ideas to be applied in his own affairs. If it does still more, if it actually influences the course which a young man may decide to take in life, it will more than have achieved its purpose.

WALDEMAR KAEMPFFERT.

THE BOOK OF MODERN MARVELS

List of Contributors

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TEACH YOURSELF
A REVOLUTION IN EDUCATION

A REVOLUTION that strikes at the very center of our school system is about to take place. The radical ideas of Dr. Charles W. Eliot, former President of Harvard and of Dr. Abraham Flexner will be tried out in Teacher's College of Columbia University, with the financial backing of the General Education Board. Living languages will take the place of dead languages. Nothing will be studied just for mental exercise, but every subject will have to stand the test of common sense, every-day use. The mere learning of the rules of mathematics and of grammar never made one a mathematician or enabled one to speak and write correctly. Scientific methods of treating these subjects will be devised that will give practical results.

The world itself will become the laboratory studied in every school. Pupils will know its trees, its plants, its minerals, its animals, its rocks and streams. They will early begin experimentation in the physical, chemical and biological fields. There will be much hand, ear and eye work, such as drawing, carpentry, turning, music, sewing and cooking. The simple things of every-day use will be mastered.

The study of wonderful modern inventions is to take the place of worn-out text books. Students will make and understand a fireless cooker, a camera, a telephone, a wireless telegraph, perhaps even an automobile and aeroplane. This modern revolutionary scheme of education will so harmonize with real life that there will no longer be the problem of getting the unwilling student to stay in school till old enough to get his "working papers." School will be more interesting than roaming the streets. Conservative, tradition-bound educators are fearful of any plan that upsets the routine to which they have been accustomed, but forward-looking people believe in giving the revolutionary program a fair trial. Why shouldn't anything be welcomed that will fit our boys and girls for the real struggle of life?

This book is not a text book, nor has it any direct connection with the scheme to reorganize the country's system of education. It is, however, the first work published in harmony with the new scheme of giving the people the kind of education they need in place of the theories that have come down from the past. A real, live, up-to-the-minute book that ought to be in every household, with an appeal to every member of the family, young or old.

JOHN A. SLEICHER,
Editor of L

THE BOOK OF MODERN MARVELS

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Seeing the Unseen

Looking at Things with Invisible Light

By R. W. Wood

Professor of Experimental Physics, Johns Hopkins University

Professor Wood is one of the most distinguished of American physicists. He has recently attracted attention to himself by ingeniously photographing the common objects around us, as well as the planets, with light that our eyes can never see. Thus he has opened an entirely new world, the exploration of which teems with boundless possibilities. The following article from Professor Wood's pen explains as simply as possible how he conducted his investigation and what may be seen in the strange world that our imperfect eyes can never behold.—EDITOR.

A photograph taken with ultra-violet light reveals no shadows. White objects appear black, and everything seems veiled in a thin fog

IF you could strike all the keys of a piano at once, from the deepest base note to the topmost treble, you would create a medley or cacophony in which it would be impossible to pick out one sound from another. White light is very much like that. It is a blending of many different kinds of light.

The analogy between light and sound is closer than may be supposed, if they are regarded merely as vibrations. The characteristic that distinguishes the lowest base note from the highest treble on a piano is pitch, and pitch depends on frequency of vibration. So it is with light. Low vibrations manifest themselves as red colors; high vibrations as violet hues. Just as there is a perfect musical octave comprised of notes each having a definite pitch or frequency of vibration, so there is a light scale, manifesting itself in color notes, each also having a definite pitch or frequency. But while the frequency of the vibrations that produce musical notes is measured at the most by thousands per second, the vibrations that manifest themselves to our eyes as light must be measured by trillions per second.

There are sounds so thin and shrill, so highly pitched that only sensitive ears can hear them. Beyond them are notes that no human ear can hear at all.

The infra-red world is as strange as the ultra-violet. The sky appears black, foliage a beautiful rich red, and there are long, heavy shadows

With light it is the same. There are octaves of light which our eyes can never hope to see. Perhaps the best known of invisible rays are those used in wireless telegraphy; they are produced by vibrations of far lower frequency than those which we see as sunlight.

When you strike the middle "C" on a piano you hear a single musical note. And so, when you look at the world about you through a pane of red glass, you see things in a single light-note, as it were. Change the color of the glass and the world appears different. The same trees, the same flowers, the same houses are there, but with one color details are obscured and with another intensified.

It is perfectly possible to view the world with invisible rays and to learn things about which we never dreamed of in our philosophy—only we must use an eye, which, unlike our own eyes, will see the unknown world for us and make a picture of it which we can perceive. The ordinary photographic camera is such an eye. The sensitized plate is extraordinarily responsive to those very high-pitched vibrations that do not affect the eye. All that remains is to strike the single note in a given octave of light, with which the world is to be viewed in order to see things as they are but as we never see them.

In order to see the world with invisible ultra-violet rays something better than glass must be employed; for glass is almost as opaque to them as a plate of sheet-iron. Quartz must be used, since quartz is transparent to them. Hence a quartz lens must be fashioned for the camera. To exclude all but violet rays from the lens a filter must be employed—a kind of sieve through which only the ultra-violet rays will pass, just as only red rays will pass through red glass. Some fifteen years ago I discovered that an aniline dye, called nitroso-dimethyl-aniline, would exclude all but the ultra-violet rays, the effect of which I wished to study. Thin films of silver are also serviceable, as well as the vapor of

bromine, contained in a rectangular transparent cell.

White ink made from Chinese white and written on white paper is practically invisible to our eyes. Photograph it with ultra-violet rays by means of the devices mentioned and it appears on the photograph as if it had been written with the blackest ink. Landscapes photographed by ultra-violet rays reveal no shadows. This means that the molecules of air or the particles of dust in the atmosphere completely scatter the rays, from which it follows that the greater part of the ultra-violet light that reaches the surface of the earth comes from the sky and not directly from the sun. If we saw only with ultra-violet light the world would appear as it does when a thin mist hovers over everything. We should, indeed, see the sun, but it would

It must not be supposed that there is but one ultra-violet light. There are indeed as many colors that we cannot see in the ultra-violet region as are visible in the rainbow. Unfortunately the camera and the sensitized plate do not give us true colors, as every kodak user knows; but they do indicate color differences in black and white. The photographs which I have made afford convincing evidence that there are a myriad hues in ultra-violet octaves. Thus all white flowers do not appear equally dark on ultra-violet photographs. White geraniums photograph much lighter than common white phlox.

In the opening paragraphs of this article light and sound were compared. It was stated that just as there are inaudible sounds there are invisible lights. There is a difference, however,

A check which was "raised" from twenty-four to twenty-four hundred dollars. The upper photograph, made with ultra-violet rays, shows the erasure plainly; the lower photograph, made by ordinary light, reveals nothing suspicious

be very dull, and there would be no shadows, just as there are none on a foggy day. Garden flowers which are white in the sun, phlox for example, become almost black. Who knows but this ability of white flowers to absorb ultra-violet rays may play some economic part in the growth in the plant? I made some experiments to answer that question, but without success. But who knows what the result would be after several generations of plants had been grown without the influence of ultra-violet light?

between the sound rays and light rays. As you go below the scale of musical notes, as you lower the number of vibrations, you hear not musical notes but distinct beats or blows. That happens when there are less than sixteen vibrations in a second. But—you hear. As you go down the light scale beyond red, the vibrations decrease in number by millions in a second. But—you do not see. In other words there is but one small octave of visible light. Above and below that octave we see nothing with our eyes.

It is obvious that the world is fully as well worth studying in light below red (infra-red) as in light above violet. When we reach the infra-red rays we are dealing with heat rays. A glass lens will answer our purpose in this case, but we must use a screen or color filter which absorbs all of the visible and ultra-violet light, while transmitting the infra-red.

Photograph taken with intra-red light. Note the black sky, the white trees silhouetted against it, and the eep shadows

As the camera reveals it, the infra-red world is as startling as the ultra-violet world. The sky appears in photographs as black as midnight; foliage snow white. The shadows are intensely black, simply because most of the light comes directly from the sun and not from the sky.

Applied to purely scientific investigation this utilization of infra-red and ultra-violet rays has vast possibilities. I have made photographic studies of the heavenly bodies with invisible rays, and the results obtained prove convincingly that many new facts can be reached in this way.

The Moon is a dead, arid, airless body which has long ceased to interest most astronomers. Every one of its many thousand extinct craters has been plotted; its great mountain ranges have all been named; and its so-called "seas" and basins have been mapped. It seemed impossible years ago to add anything substantial to our knowledge of the Moon. I made some experiments at my summer home on Long Island with a horizontal reflecting telescope of fifty-six-foot focus and fourteen-inch aperture to ascertain what might be revealed if the Moon were photographed with ultra-violet light. While there is very little difference between ordinary photographs of the lunar surface and those made with ultra-violet radiation alone, there is enough that is significant. The brightest of all extinct lunar craters is called Aristarchus. Photographed with ultra-violet rays, Aristarchus shows a dark patch which is not to be seen on a photograph made with visible light. I made an enlargement of the region in which this crater appears, and it is evident that there is in its neighborhood a large deposit of some material which can be revealed only by ultra-violet rays. These photographs of the Moon prove that by systematically studying the lunar surface with invisible rays, we may some day discover what the Moon is made of almost with as much certainty as if we could analyze a piece of it in an earthly laboratory.

In the late autumn of last year, through the courtesy of Professor Hale, the great sixty-inch reflecting telescope of the Mount Wilson Observatory in California was placed at my disposal for four nights. The instrument is the largest of its kind in the world. Photographs of Saturn and Jupiter were made

Infra-red Yellow Violet Ultra-violet

Photographs of Saturn made by Professor Wood with various rays, showing how much more is revealed by some rays than others

by means of infra-red, yellow, violet and ultra-violet light.

Both Saturn and Jupiter are striped with belts which have been the subject of much discussion among astronomers. Study the accompanying photographs and you will see how different is the aspect of the planets when photographed with different rays, whether visible yellow or invisible infra-red or ultra-violet. The belts on the ball of each planet, which can be seen with the eye in a telescope and which are very distinct on photographs made with visible yellow rays, vanish almost completely when photographed with infra-red rays. When ultra-violet light is used a remarkable transformation of the planets occurs. A broad dark equatorial belt surrounds each planet, and a large dark polar cap appears. This equatorial portion is the brightest part of each planet when photographed with visible yellow light. When ultra-violet is employed the bright belts vanish. The equatorial dark belts are still recorded, but they are slightly narrower than when photographed in violet light. Moreover the dark polar cap has decreased in size.

Variations in the intensity of the inner and outer ring of Saturn are also shown in the different photographs. The surface features of both Saturn and Jupiter have been repeatedly photographed, but not with the result of adding much to our knowledge. At last we have a method which may enable the astronomer to interpret the puzzling belts intelligently. It is much too early to venture an opinion. Much work remains to be done with the spectroscope. Perhaps it may turn out that the bands of Saturn may be due to some substance which has not been made in any earthly laboratory or to some substance, which has never been studied in layers thick enough to bring out the characteristic appearance. It is also possible, though hardly probable, that the belt is due to a fine mist or dust which absorbs violet light; but it seems unlikely that such a mist would appear dark for the simple reason that it would reflect equally as much light as it absorbed. As a venture we might attribute the belt to chlorine gas, which absorbs violet and ultra-violet light powerfully and is transparent to yellow light. When we recall the enormous quantity of chlorine locked up in the salt of the ocean it is perhaps possible that large quantities may exist free in the atmosphere of young planets like Jupiter and Saturn.

It seems highly probable that extremely valuable results may be obtained if these methods are applied to the planet Mars. Unfortunately, at this time Mars is too far away, and the photographs which I made show nothing of interest.

Infra-red Yellow Violet Ultra-violet

Photographs of Jupiter made by Professor Wood with different rays

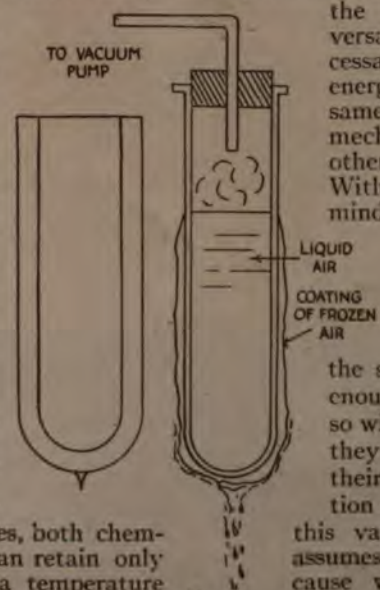
Producing the Coldest Cold

Think of 400 degrees below zero!

Think of gases that have been squeezed and cooled until they look like water!

Burning a piece of cold-rolled steel in liquid air. The liquefied oxygen combines so rapidly with the metal that a furious heat is produced

At right: By using a vacuum pump the rate of evaporation can be increased enough to freeze the air contacting the outside of the tube



AMONG the more startling discoveries of the past decade is the production of temp·ratures reaching as far as 400° F. below zero. It is the attainment of these low temperatures that has brought the chemist and physicist into a new world; for when matter is subjected to such degrees of cold, there is a complete alteration of both its chemical and physical properties.

Each substance on our earth has individual properties, both chemical and physical, which it can retain only at a specific temperature—a temperature which nature set for it. If we alter this temperature by artificial means the substance will gradually assume a different physical state. This change of state is "forced" upon it, and when we withdraw the artificial means of changing its temperature, nature promptly transforms the substance into its original state. As an example, water at ordinary temperature is a liquid. If we heat it to 212° F. it becomes steam, and if we cool it to 32° F. it becomes a solid.

What is known as the kinetic theory of matter tells us that all molecules are in perpetual vibration at a tremendous velocity and are continually colliding with one another. This rate of molecular vibration produces the temperature of matter—the higher the rate of motion the greater the temperature and vice versa. The molecules are incessantly giving out their energy of motion and at the same time are receiving these mechanical impulses from other particles of matter. With these simple facts in mind, we may continue more intelligently.

When we boil water we merely impart energy in the form of heat to the molecules. If the source of heat is intense enough, the particles become so wild in their vibration that they come out of the range of their natural mutual attraction and pass off as vapor. If this vapor is cooled it again assumes the liquid state, because we have taken energy

from the molecules and have caused them to return to their natural degree of vibration. If we continue to cool the liquid, we still further paralyze the motion of the molecules, until they become so crowded together that we have a solid—ice.

To Change a Gas into a Liquid—Cool It

Now, then, in the light of the knowledge imparted in the foregoing paragraphs, if we wish to change a gas to a liquid we must cool it. This is true. If sulphur dioxide (a gas obtained by burning sulphur) is cooled to a few degrees below zero, it condenses into a liquid. As soon as the artificial means of cooling the gas is withdrawn, it rapidly assumes its natural state, as gas, by evaporation.* Now to get back to its natural state it needs a specific amount of heat to make its molecules vibrate at a definite rate, that which nature determined. Where does it get this heat? It abstracts it from its surroundings so rapidly that a still further degree of coldness is realized as the gas is formed from the liquid and passes off carrying with it its natural amount of heat which it has greedily robbed from material in contact with it. For commercial purposes liquid carbon dioxide is stored under great pressure in durable steel cylinders. If the jet on the cylinder is opened, the liquid evaporates so rapidly that the temperature of the container is soon lowered far below zero, and a solid formation of carbon dioxide appears on the mouth of the jet.

Part of condenser in a laboratory refrigerating apparatus. The chamber is so cold that frost is formed. Yet liquid air would boil briskly if placed on the tubes

The tin cup on the right was frozen by immersion in liquid air, after which it was easily broken

At left: What remains of a large rubber cork after it has been frozen and struck with a hammer

At left below: Two screweyes frozen into a block of mercury so solidly that they sustain the weight of two flatirons suspended from a great height

Professor Dewar liquefied hydrogen and helium in the laboratory of the Royal Society by a different method from that of rapid evaporation. The principle applied by him is based on the fact that a compressed gas allowed to expand freely greatly lowers its own temperature. Lord Kelvin made known this fact early in his career, and it was commercially utilized by Linde, a German scientist, and by Hampson, an English physician. Both workers were laboring independently of each other.

* This is assuming that the gas is not stored under pressure, which prevents evaporation.

How Expansion Cools

It was found that if the compressed gas was allowed to expand through a small opening its temperature was still further lowered.

Working with these facts in mind, Linde and Hampson perfected a process by which they were able not only to obtain far lower temperatures than with the old evaporative method, but to liquefy gases that had hitherto resisted all efforts. The apparatus used consists of a coil of pipe (see diagram) through which the compressed gas is permitted to pass and expand through a small opening at the end. First, the air is brought to a pressure of 200 atmospheres by means of the compressor. It is discharged from this through the valve *N* and into the water-cooled jacket *C* where the heat of compression is abstracted. From there it flows through the smaller coiled pipe which is concentrically arranged within the larger one. As the air reaches the expansion valve *H*, and flows into the heat-insulated chamber *E*, its temperature is greatly lowered. The cooled air then rushes back through the larger pipe and lowers the temperature of the succeeding air coming through the smaller pipe. It will be seen, then, that the air emanating at *H* will gradually become colder until a liquid state is reached.

Driving a nail with a hammer made of mercury frozen solid by immersion in liquid air

Dr. Hampson's apparatus for the liquefaction of gaseous matter was designed with such ingenuity and constructed so perfectly that compressed air at ordinary temperatures passed through the coil came out as a liquid at the nozzle in approximately six minutes.

When attempts were made to liquefy hydrogen by this means, it was found that instead of being cooled by expansion its temperature was actually raised. Later it was discovered that hydrogen obeyed this law only when its substance was first cooled by contact with some refrigerating medium. In the apparatus employed to-day for the liquefaction of hydrogen, the gas is first reduced to a low temperature by means of solid carbonic acid and liquid air. By this means, Dewar also brought helium to a liquid state.

Gases That Look Like Water

The fact that these liquid gases cannot be kept in ordinary containers should be readily appreciated by the reader when it is understood how rapidly they abstract heat from their surroundings. If liquid air is poured into an ordinary glass vessel it immediately starts to boil and will reduce the container to bits. It must be remembered that liquid air has a boiling point about 180° Centigrade below zero. If liquid gases, then, are to be kept any length of time they must in some way be insulated from the heat of their surroundings. It has been known for a long time that nothing but tangible matter will conduct heat waves. Dewar ingeniously took advantage of this fact in a method by means of which he can preserve liquid gases over a considerable period of time. He uses a glass vessel with two walls between which a high vacuum prevails. If a small

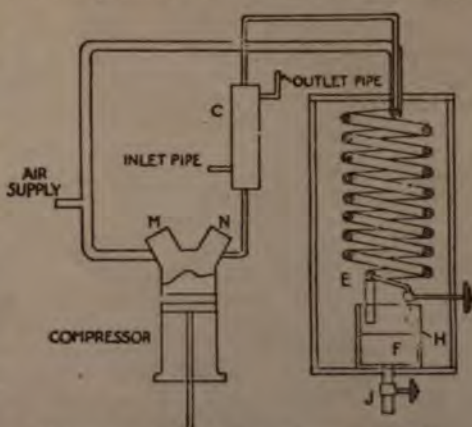


Diagram explaining the apparatus used in the Linde process for the liquefaction of gases

amount of mercury vapor is left between the walls, it will be solidified and deposited upon the walls of the vessel upon the entrance of a liquid gas. In this manner it acts as a mirror and reflects heat waves that impinge upon the outer surface of the container. Thus was the familiar commercial vacuum bottle created.

Now that the methods for producing low temperatures have been explained, we will briefly review some of the more wonderful phenomena that occur when matter is subjected to such severe low temperatures.

Strange Things That Happen When Gases Are Liquefied

If a piece of silver forming part of an electrical circuit is immersed in liquid air and held there, it undergoes a physical modification that reduces its electrical resistivity to an almost unnoticeable amount. It was predicted by physicists that at absolute zero a metallic substance would offer no resistance to an electrical current.

Professor Dewar discovered that if a magnet was repeatedly immersed in liquid air, its magnetic influence was not only intensified but permanently increased. Also, curiously enough, oxygen may be separated from the nitrogen in liquid air by magnetic means.

A student of physics would naturally ask: Will a liquid gas alter the color or light-absorption of a substance? The answer is, yes. Understanding, as we do, that the color of a substance depends upon the wavelength of the ether waves of the spectrum it absorbs, it would be natural and tempting for one to conclude that it was the great contraction of the molecules that affected its wave absorption at this temperature. We must be more cautious than positive in making this pretty assertion as final at this time. It has been found, however, that at these low temperatures red things become yellow and yellow things white and so on.

It has been found that if a bell constructed of pure lead is subjected to such a low temperature, it has a pure metallic ring when struck a sharp blow. Bits of vegetable matter immersed in liquid air become so hard and brittle that they may be powdered in a mortar. In the laboratory of the British Royal Society, it was found that the bacteria could not be destroyed even by the lowest temperatures.

The "absolute zero" has been set by physicists as being 273° Centigrade below zero (459.4° Fahrenheit below zero). In this condition matter will have absolutely no heat. The nearest approach to this has been in the liquefaction of hydrogen or —254° Centigrade (—425.2° Fahrenheit).

Transforming a Railroad Water-Tank into a Home for Two

AN OLD water-tank in a Western town stood idle until an enterprising citizen came along and recognized in it the making of a home for himself and his wife.

He set to work with carpenter's tools, and in a week he had the interior fitted up comfortably. He cut windows where he wanted them and made a door large enough for the champion tall man in the United States to walk through without ducking his head.

Love in an abandoned railway water-tank. There is even an upstairs and a guestroom in this improvised home

To disguise the tank-home as far as possible and also to add an element of architectural beauty to the whole, he fitted the roof with extensions, placing windows in the extremities.

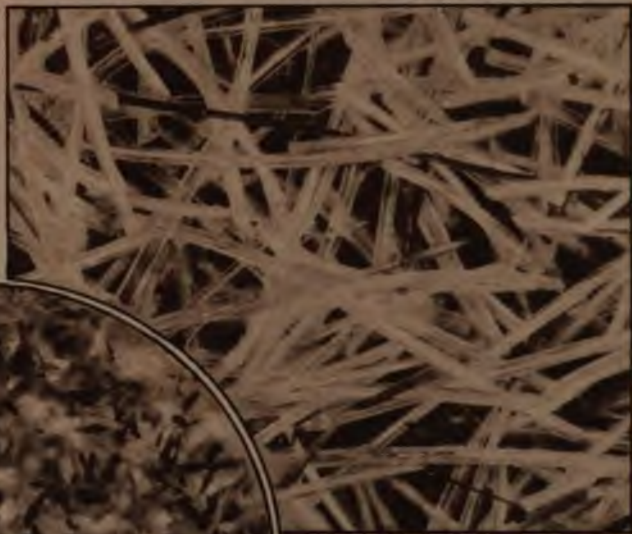
This gave him the happy thought of building an upper room to the structure. Now he has plenty of room for guests, since he has finished off and furnished the addition as a spare chamber. A chimney was also added and stoves were installed.

Your Razor Is Like a Scythe

IF we had eyes like microscopes, the process of shaving would seem not much different from mowing with a bush-scythe. A razor is practically a miniature bush-scythe, and its cutting action is similar. Some of the bushes are cut squarely across and others at an acute angle. When the bushes are upright, and the scythe is swung directly against them, the cut is made nearly at a right angle. But if the bush man cuts his bushes a little too high and then wants to go over them again, "grubbing" them down to the ground, as he would phrase it, especially if the bushy stumps are in a marshy place where the ground does not hold them firmly, he strikes at them several times in succession, and the cut is likely to be more and more at a slant, depending upon the resistance with which they hold their own in the ground.

When the barber applies a heavy coat of lather to a long beard, the lather tends to hold the hair upright. In the first shaving, the microscope shows that the cuttings are nearly at a right angle to the length of the beard, but the "second time over," when the call is for "a close shave, Mr. Barber," short rapid strokes are made, several times repeated. When the lather is off, the barber will occasionally wet his fingers, because the face gets too dry. Indeed, there is nothing to maintain the perpendicularity of the beard. It bends over and the barber rapidly whacks away at it like the bushman grubbing the bushes to the ground.

In connection with these views of the human beard, there is something very surprising in Dean Swift's "A Voyage to Brobdingnag," where he describes a mythical traveler to the land of the giants and what he had to say of giants' beards. He writes:



Microscopic views of the cuttings after shaving. The long hairs in the picture above are from a three days' growth of an Albino Irishman. Note that the hairs were cut nearly at right angles

Cuttings the second time over

"I used to attend the king's levee cnce or twice a week, and had often seen him under the barber's hand, which, indeed, was at first very terrible to behold: for the razor was almost twice as long as an ordinary scythe. ....I once prevailed on the barber to give me some of the suds or lather, out of which I picked forty or fifty of the strongest stumps of hair. I then took a piece of fine wood, and cut it like the back of a comb, making several holes in it at equal distances with a needle.....I fixed in the stumps so artificially, scraping and sloping them with my knife towards the points, that I made a very tolerable comb which was a seasonable supply, my own being so much broken in the teeth, that it was almost useless."

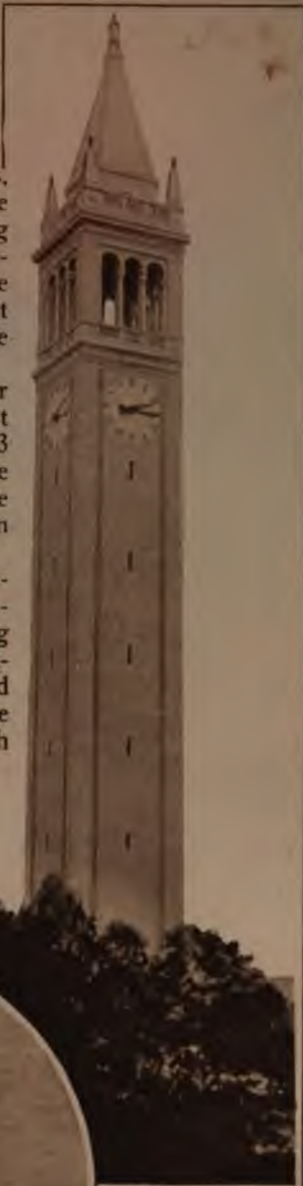
Rocking a Three-Hundred Foot Masonry Tower with Your Hand

BY the mere pressure of your hand you can rock "Sather Campanile"—the three-hundred-and-two-foot memorial tower just completed on the campus of the University of California.

In order to minimize the danger from earthquake shocks, the architect, Professor John Galen Howard, and the engineer, Professor Charles Derlith, Jr., so built the strong steel frame of the Campanile that cross-bracing is eliminated at alternate stories. As a result the vibration of the tower is like that of a steel rod one end of which is thrust in the ground. In an earthquake the tower would vibrate like a tree.

According to Professor Elmer E. Hall's tests, the tower has a vibration period of 1.13 seconds. By pressing against the steel frame at the top of the Campanile every 1.13 seconds he was able to rock the tower, so that earthquake recorders (seismographs they are called) registered the vibrations. However, the amount of motion was less than the thickness of this sheet of paper.

The plan on which the tower was built is to prevent a re-enforcement of the rocking caused by an earthquake vibration. For instance, a child can set a hammock swinging violently simply by pushing at the right moment, no matter how heavy the load may be. If the pushes are not timed correctly, the swinging is retarded. It is the same with the Campanile. The plan is to prevent cumulative swaying, such as would occur if the period of the earthquake and the vibration of the tower were the same, and such as would cause the structure to collapse. Mrs. Jane K. Sather erected the memorial to her husband.



The pressure of your hand will swing the bell-tower at Berkeley, Cal., which in height is second only to Washington Monument. It was erected, as a memorial, by Mrs. Jane K. Sather at a cost of two hundred and twenty-five thousand dollars.

Cotton Is Contraband of War

By Hudson Maxim

will make a shirt to hide your or blast a subway to make transportation easier

COTTON happens to be the best combustible element to combine chemically with nitric acid so as to produce a high explosive, and also to serve as the principal ingredient for the manufacture of smokeless powder.

A bale of cotton may, therefore, be considered a bale of guncotton in embryo.

There are many kinds of nitrocellulose, depending upon the so-called degree or character of nitration, that is to say, upon the way in which it is treated with nitric acid and the strength of the nitric acid.

When ordinary cotton is immersed in nitric acid, the cotton absorbs oxygen from the nitric acid, but not as free oxygen, because the oxygen is taken up in combination with nitrogen. But the weight of the oxygen absorbed is much in excess of the weight of nitrogen, the nitrogen acting merely as a carrier of the oxygen. The appearance of the cotton is not changed to any appreciable

extent, but the weight of the cotton is considerably increased.

The oxygen which the cotton absorbs from the nitric acid is sufficient to consume all of the cotton without atmospheric air, so that when guncotton is put in a confined space and set on fire it explodes with great violence, producing what are called carbon dioxide and carbon monoxide, with free nitrogen and steam.

When the cotton is immersed in the nitric acid the acid takes water out of the cotton, which dilutes the acid. But the cotton gets the best of the bargain, because the weight of oxygen and nitrogen which the cotton receives is in excess of the weight given up by the cotton.

In order to keep the nitric acid bath strong enough to act on the cotton, and to minimize the acid, it is necessary to add sulphuric acid to absorb the water, and it takes about three parts sulphuric acid to one part of nitric acid to make a proper mixture for this purpose. The sulphuric acid, however, has no effect whatsoever upon the cotton. It merely acts to absorb the water liberated from the cotton.

There are several ways in which the cotton is treated with the acid mixture. The oldest and simplest was merely to immerse the cotton in the acid, and when it was thoroughly nitrated to place it in a centrifugal machine and wring out the acid and throw it into an excess of water to wash out the remainder.

From the portrait by S. J. Woolf.

If you want to know how to write poetry or blast a subway, lay out a garden or design a battleship, ask Hudson Maxim. It is no off-hand slap dash opinion that he will give, but a well-reasoned statement. For Maxim believes that everything could be reduced to a science, whether it is writing sonnets to your lady's eyebrow or defending the country against foreign invasion.

But Maxim is above all an authority on explosives. That is why we asked him to write this article for THE BOOK OF MODERN MARVELS. *He invented the process of making the multi-perforated smokeless powder used by the United States. His Maximite, adopted by the United States Government, was the first high explosive which could be sent through armor plate and burst inside of a ship. That achievement in itself was enough to make any man famous. But then he is also the inventor of Stabilite, a powder which we have every reason to regard as important because it can be made quickly in an emergency. A torpedo invention of his, intended to do away with compressed air, has also been bought by the Government. Mr. Maxim is a member of the Naval Consulting Board.*

The way that is employed principally by the United States Navy is to do the nitrating in a centrifugal machine and when the nitrating is complete to set the centrifugal machine in motion, which extracts the acid from the nitrocellulose. Thereupon the nitrocellulose is quickly and thoroughly washed.

After the washing process is completed there is a quantity of acid remaining, and also there are contained in the nitrocellulose certain unstable compounds. These are removed by thoroughly boiling the nitrocellulose in a large excess of water.

After this is done the nitrocellulose is pulped in an ordinary pulping machine, like that used in making paper pulp. When this is thoroughly done the finely pulped nitrocellulose is gathered and pressed into cylinders. It still contains a considerable percentage of water, which must be removed in order to dissolve or gelatinate it as a step in converting it into smokeless powder.

This is done by forcing alcohol under pressure through the mass of pulped

ake from the top, the water
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iven entirely out at the bot-
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very important.

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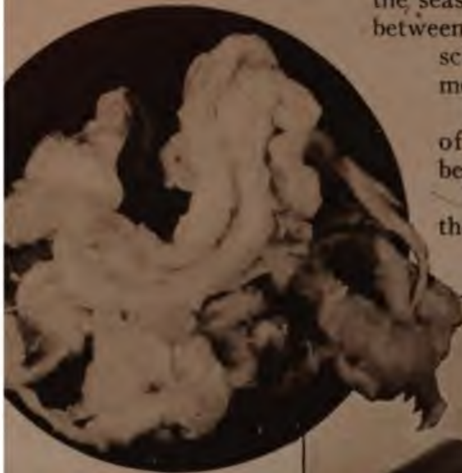

ated and ready to be into smokeless powder se). Grains of smoke- (nitrocellulose) are per- hat they can burn inside utside, thus controlling of gas production

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method of producing nitro
from the air, nitric acid
n, by means of the electric

and that today the Germans are not only able to make all the nitro compounds they need for the purposes of explosives, both high explosives and smokeless powder, but also what they require for fertilizers for the farmers.

With a nation of scientists, chemists and inventors like the Germans, it is entirely impossible to stop them from producing explosives in any quantity they may desire, entirely independent of any class of imported materials, because although the English may blockade the seas they cannot establish a blockade between the genius of the German scientists and the German government.

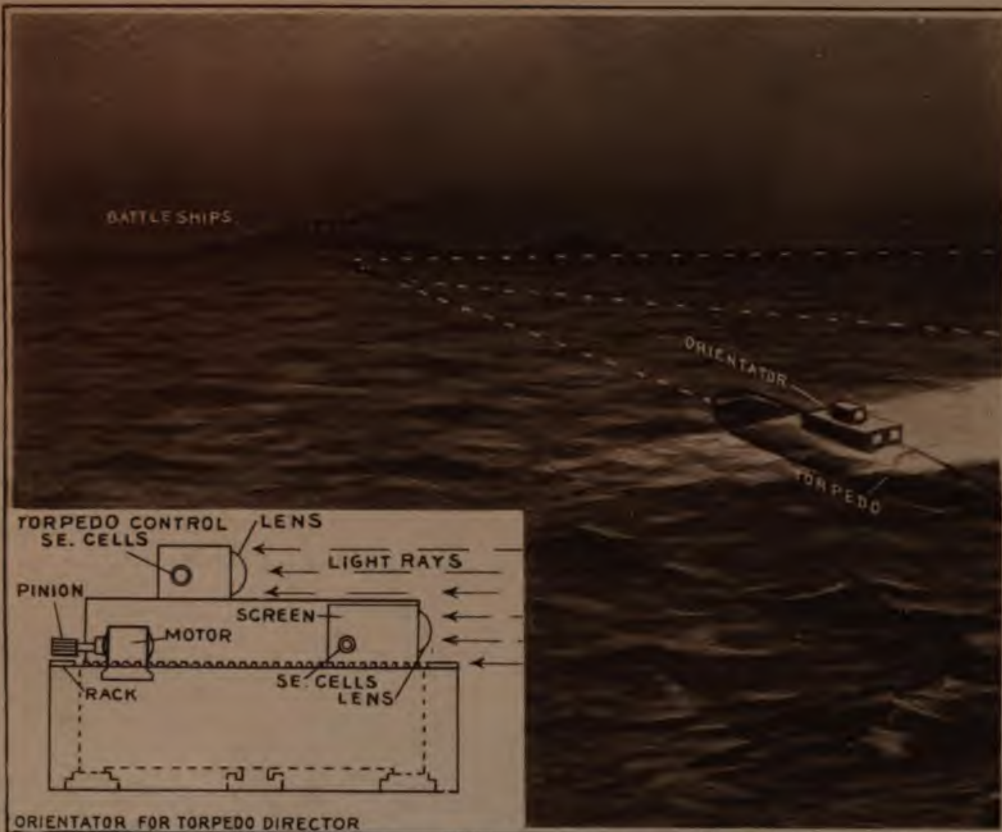
It is very curious how the trials of war often result in the most beneficial effects upon a nation.

When the English established their famous blockade under their Continental system in Napoleon's time, the French were compelled to resort to some other means than importation to get their sugar. Consequently, they developed the sugar beet, and planted it in enormous quantities, with the result that France introduced the sugar beet industry, which has been of vast importance to that nation ever since.

Likewise, the English blockade against Germany today is compelling the Germans to develop their internal industries in a most phenomenal way. They have solved the nitric acid problem, and very likely they will continue, after the war is over, to make their nitric acid and other nitro compounds from air. What is more, they will probably compete successfully with the natural nitrate of Chile.

If you want to know why cotton is contraband of war this picture will tell you. It shows a Russian mine which ran ashore on the Baltic Sea and which the Germans exploded. As in all modern mines the charge was composed of a high explosive made by the proper chemical treatment of cotton. The war is actually being fought with cotton—cotton grown upon the peaceful southern plantations of the United States. So long as cotton is obtainable these high explosives can be manufactured in great quantities. Naturally, the warring countries who can secure unlimited control of the cotton supply make themselves just that much more formidable to their enemies. Great Britain watches with never-closed eyes every shipload of cotton leaving the United States

You read of "craters" in the newspapers—great holes produced either by the explosion of some huge shell or of some subterranean mine. This is a photograph of a type of crater produced by a mine. Surely the men in this war live on the crests of volcanoes—not figuratively, but literally. At any moment the soldiers in the trenches may be blown to atoms by mines charged with high explosives made from guncotton. The tremendous expansive power of guncotton when exploded, will lift many million times its own weight of matter, with a suddenness that prevents any possibility of escape for those who are within its range



As a human being, you have the power of running toward the thing that you see. You have eyes—organs sensitive to light. Suppose a torpedo had eyes. Suppose that it were

A Torpedo with Eyes

By Walter Bannard

SUPPOSE we have at our command torpedoes that obey the orders of a single master; torpedoes that heed faithfully the wish of an operator expressed through a simple directing apparatus; torpedoes that can be projected six or eight miles through the water, being constantly under the control of the man and his machine on shore; in a word, torpedoes which carry out the intention of one man to destroy an oncoming vessel of the enemy. This torpedo would simply be the projection mechanically, of this man's will to destroy that vessel.

Theoretically, we have the materials at hand to render this achievement possible. In fact, the "light-directed torpedo," as it is called, is virtually on the threshold of reality, but it has not yet crossed the threshold.. This delay is caused by the present unreliability of a chemical substance, selenium, and it is upon selenium that the eventual success of the light-directed torpedo depends. In an article on the Hammond electric dog, appearing elsewhere in this issue, will be found an explanation of the way in which selenium does the work.

A boat has been directed wirelessly from shore—most all of us have read of that—and a boat can be directed by wire-

given the power either of running toward the thing it sees, or of fleeing from it. That is the basic idea of the weapon here pictured. Its movements are absolutely controlled by the beam that comes from a searchlight

less from shore now; can be made to stop, start, stop and swerve to right and left. Nevertheless, the secret of a reliable, light-controlled torpedo — for light-rays are more desirable than wireless—has not yet been entirely solved.

John Hays Hammond, Jr., who has been widely heralded for his wireless experiments, joined hands not long ago with B. F. Meissner, an electrical engineering student of Purdue University, and together they designed and constructed an ingenious mechanism on wheels that would trail after a pocket lamp held before its selenium eyes in a most uncanny way. Using this same principle, a torpedo with selenium eyes that will follow the directions of light rays from shore, will eventually be developed; soon, it is to be hoped.

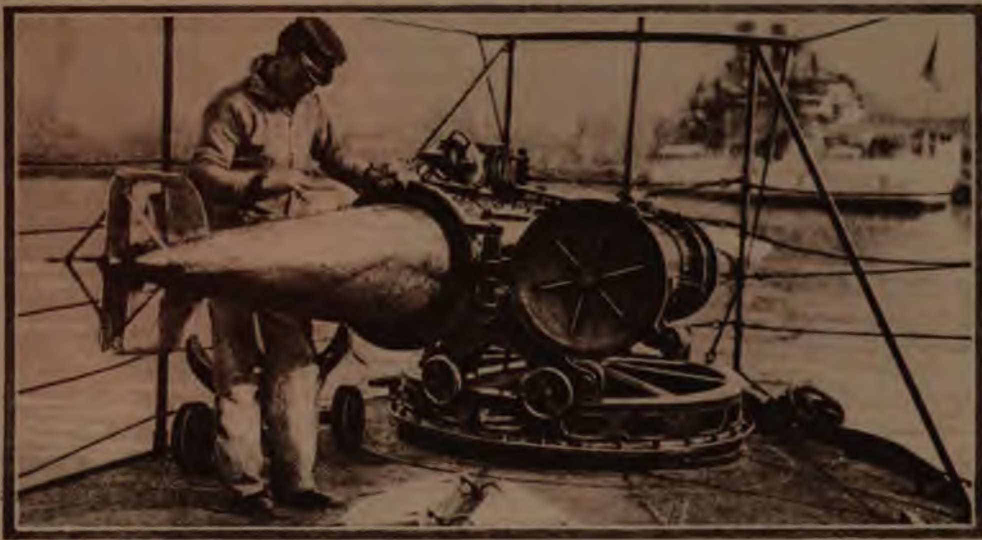
There have been two big obstacles to prevent the evolution of a controllable torpedo:

One is the lack of a suitable apparatus for transmitting sufficient light to control the mechanism at useful distances; the other is to accomplish the directing without interference from the enemy's ship. The solution of the problem demands a more scientific knowledge of selenium and its chemical properties.

Suppose that day had come and a hostile ship was booming into the harbor of New York, grimly determined to scatter our fair buildings to the four winds.

"Sic!" says the man on shore.

Almost with human intelligence, the glistening steel cylinder darts out towards the enemy, at a forty-mile-an-hour clip. Though at present such an occurrence is only a fancy, it may become a reality.



Torpedoes are launched from the decks of torpedo boats and cruisers by means of adjustable, gun-like tubes known as launching tubes. The torpedo is placed in the breech of the tube and the gate closed. A puff of compressed air admitted into the chamber in back of the torpedo ejects it into the water.

Providing a Torpedo with Ears

By Edward F. Chandler

THE *author of this article is a recognized authority on torpedo construction. He assisted Capt. Leon in working out the sound-control torpedo, described in this article, and he has had much practical experience in the construction of the Whitehead torpedoes used in the United States Navy. As the inventor of a new gyroscopically-controlled torpedo his work has attracted the attention of the United States Government and foreign governments. The following article may therefore be considered an authoritative exposition of a very ingenious type of weapon.*

—EDITOR.

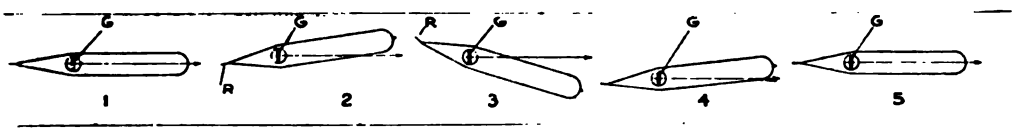
AS a piece of mechanism the torpedo is probably the deadliest and certainly the costliest weapon of modern warfare. In its cruelest modern European form it carries about 400 pounds of guncotton in its "war head," and it costs about $7,000. If it once hits a ship, either total paralysis or complete destruction is sure to follow.

But what makes it hit its mark? Remember that this deadly contrivance must travel through the water for a distance of at least half a mile if discharged from a submarine boat, and a distance of from five to seven miles if launched from a battleship during an engagement. What keeps this $7,000 worth of death on its course?

To answer that question we must first find out something about the construction of a torpedo. Imagine a cylinder twenty-one feet long (the size of the latest United States model), in the nose of which a charge of guncotton is contained; imagine behind the charge a compartment containing air at a pressure of a ton to the square inch; imagine in back of this air tank a compressed

air turgine and propellers—imagine all this and you have before you the vitals of a torpedo—all but its brain.

the diaphragm would overcome the spring; the rudders would be thrown down and the torpedo would rise until



Bringing a Torpedo Automatically Back on Its Course

THIS *conventional diagram represents several positions of a torpedo as it would appear at different points along its course. In each of the views G represents the gyroscope, the gyroscopic axis being indicated by the long arrow, which points in the general direction of the torpedo's travel. In view 1 the torpedo is parallel with its gyroscopic axis and traveling in a straight line. In 2 the torpedo is turning to the left; consequently the rudder R has been swung slightly to the right, due to the fact that the center line of the torpedo is not coincident with the gyroscopic axis, as shown.*

The rudder having been turned to the right, the torpedo is steered back across its course, and in position 3 it has passed the meridian on the other side; consequently the rudder is corrected to the left, which again carries the torpedo back across the meridian, as shown in position 4. At position 5 the torpedo is virtually back on its gyroscopic line.

In this country it has been the practice to employ a steering mechanism in which the rudder is swung definitely in a hard-over position either to the right or to the left with no neutral or center stop. This causes the torpedo to steer a crooked course. Since the rudder is provided with very little throw, the weapon deviates but slightly from its impressed direction.

The Mechanical Brain of the Torpedo

A mechanical brain of some kind is obviously necessary; for this death-dealing torpedo of ours must be guided automatically upon its course and must never swerve very far from it. Some way must be found to keep it at a set depth and to prevent it from swerving to the right or to the left.

The ocean itself, paradoxically enough, holds the weapon at a fixed depth. Every one knows that the pressure of water increases as you near the bottom. If it were not so divers could perform even more difficult feats than now lie within their powers. The water is allowed to press against a diaphragm on one side; against the diaphragm on the other side a spring pushes. It is obvious that by adjusting the tension of the spring a perfect balance can be maintained between the sea water on one side of the diaphragm and the spring on the other. Connect the diaphragm with horizontal rudders and you have an automatic depth regulating gear. If the torpedo should dive below the set distance, the pressure of the water on spring tension and water pressure were absolutely counterbalanced. The opposite effect occurs when the torpedo is traveling too high and the spring tension is greater than that of the water pressure.

The Wonderful Gyroscope—A Never-Failing Compass

To prevent the torpedo from swerving to the right or to the left the gyroscope is employed—the most puzzling, the most mysterious device in the whole realm of machines. A gyroscope, generally speaking, is any rapidly rotating body. A spinning top is a gyroscope. So is a rapidly turning flywheel. It is one of the properties of a swiftly turning wheel that it resists any attempt to throw it out of its plane of rotation. It is this property of a gyroscope which is applied in automatically keeping the torpedo on its course.

Now the gyroscope of a torpedo consists simply of a small, heavy flywheel, mounted so that it may freely revolve in a frame which is in turn pivoted in what is known as a gimbal ring. In other words, the wheel can swing around

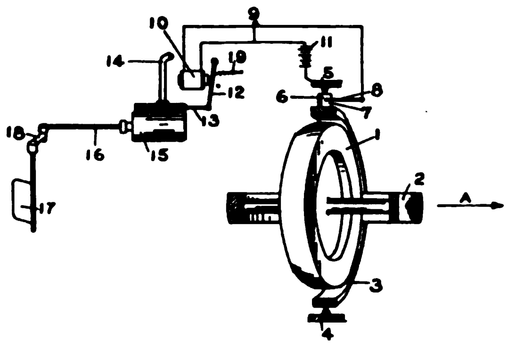
both horizontally and vertically. Before the torpedo is launched the frame carrying the flywheel is locked, so that the wheel itself is held in a fore and aft position in the torpedo. While it is thus locked the wheel is spun at high speed. When released it will hold its plane of rotation even though the torpedo may be swung around horizontally, so long as the spinning continues. By connecting rudder with the gyroscope, the torpedo by the very act of departing to the right or to the left, will swing them and thus bring itself back again to the predetermined course. If the torpedo curves to the right, the rudder moves to the left; if the torpedo starts off to the left, the rudder shifts over to the right. The torpedo always travels along the line passing through the plane of the gyroscope's rotation, and the plane or rotation always lies along the line which the torpedo is supposed to take — the line in which the torpedo is pointing at the instant the spinning wheel is set free. It is wonderful, indeed, to think that a little spinning wheel keeps a torpedo on its course.

How a Torpedo Is Launched

A torpedo is discharged from what is known as a launching tube by a puff of compressed air. At the top of the torpedo is a little latch, which is tripped as the torpedo passes out of the launching tube, so as to cause the compressed air to operate a little engine which spins the torpedo. The air is automatically cut off and the gyroscope released when a sufficient speed of rotation has been attained. Compressed air is also supplied to the propelling engine of the torpedo at the same time. All this must happen during the fraction of the second required for launching.

It is evident that a torpedo is nothing but a little ship, traveling through the water at railway speed, guided by a mechanical helmsman, and kept on its course by an automatic compass — its gyroscope. Surely it would be difficult to imagine anything more mechanically intelligent. Unlike most human beings, a torpedo is absolutely obedient: it does exactly what it is told.

Perfect as this



How the Gyroscope of a Torpedo Works

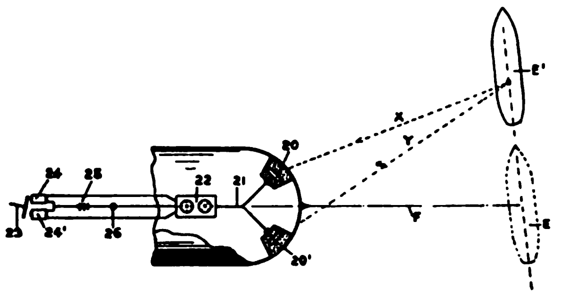
In the drawing, 1 is a fly wheel, and 2 the frame carrying the fly wheel, half of which has been removed to expose the wheel. This frame is pivoted in a horizontal plane in the ring 3, which has also been broken away, as shown. Ring 3, which carries the fly wheel in the frame 2, is pivoted at 4 and 5 in the vertical plane in a suitable support or frame. It is evident that the gyroscope fly wheel 1 is not only free to revolve about its axis, but also to swing around its vertical and horizontal pivots.

For the convenience of illustration 6 represents an insulated member carried by the ring 3, and having a contact surface 7. Resting against the contact surface is a brush 8 which is connected in circuit 9 with an electro-magnet 10 and a battery 11. In the picture the current is on and the magnet energized; in consequence the armature 12 is drawn over. The armature carries a balanced valve 13, which controls the flow of compressed air through the pipe 14 to the turbo-motor 15. The piston rod 16, of the turbo-motor, also acts as the rudder rod for the horizontal-course steering-rudder 17, on the post of which is a crank 18

When the gyroscope swings around so that the insulated portion 6 is carried under the brush 8, contact is broken and the electro-magnet 10 deenergized. The spring 19 then instantly pulls the armature 12 and consequently the valve 13 to the opposite extreme position, thus causing the rudder 17 to shift over. The arrow A represents the general direction in which the torpedo is supposed to be traveling, it being understood that the gyroscopic fly wheel 1 is revolving at high speed.

mechanism seems to be, nevertheless, it has its defects. It is not quite modern enough. Launch it from a submarine at a battleship a half a mile or a mile distant, and it will perform its task with ghastly perfection. But launch it at a dreadnaught seven miles away—and this is the range at which modern sea battles are fought—and it is doubtful if it will ever find its mark. Why? Firstly, because it is hard to hit a moving target at long range, if not actually impossible; secondly, the gyroscope gradually "dies" down like a boy's top which has spun too long. Once the speed of the spinning flywheel drops below a certain critical point the torpedo no longer keeps upon its course. Unfortunately this slowing up of the gyroscope occurs just when the torpedo should be most trustworthy; just when it must adhere most surely to its course—in a word, at the moment of striking.

Other factors must also be considered. The speed and direction of the vessel which fires the torpedo must be considered, so must the distance to be covered, the time allotted to reach the target, and the target's speed and direction. Fire point blank at a battleship only three miles away and the torpedo will miss its mark; for by the time the 35-knot weapon covers the intervening distance the ship will be many yards beyond the point at which the torpedo was intended to inflict its destruction. Clearly the torpedo must be shot ahead of its mark, and it must be so timed that the two will inevitably meet. It is so difficult to make all these calculations that long-range torpedo f—



The Ears of the Leon Electrical Torpedo and How They Hear a Hostile Ship

THIS *is a schematic diagram of the apparatus invented by Captain Leon to control torpedoes by enabling them literally to hear the propellers of a hostile ship. The "ears" or sound responsive devices 20 and* 20^{1} *(microphones) are enclosed in a suitable casing located within the head of the torpedo and surrounded by a sound-transmitting medium, such as water or gelatine. The sound passes directly through the shell of the metal head, which is about one-sixteenth of an inch thick.*

The two microphones are connected by an electrical conductor 21 with an adjustable device 22. The rudder 23 is here shown directly controlled by the magnets 24 and 24', which are electrically connected with the adjustable controlling device 22 to receive energy from a battery 25 when the switch 26 is automatically thrown into operation. This switch 26 forms part of a clock work mechanism which throws out the gyroscope control and connects the sound control, after the torpedo has traveled within the range of the sound vibrations sent out by the propellers of the enemy. It is important that the torpedo should not turn upon its own ship in response to the beating propellers. Hence the torpedo is made to travel under gyroscopic control for a certain distance, before the "ears" are allowed to operate.

To illustrate the operation of this apparatus, let E represent the position of the enemy when the torpedo is originally discharged and F the intended line of fire. Had the torpedo continued as originally intended it would have missed its mark, the enemy having proceeded in the meantime to the position E'. As soon as the sound device is released for operation by the clock switch 26, vibrations are conveyed to the torpedo along the lines X and Y. Rays traveling along the line X strike the microphone 20 squarely, whereas microphone 20^{1} *is out of the zone of influence. Clearly, the microphones are out of balance; one "ear" is hearing more than the other. The magnet 24 is therefore energized, and the rudder 23 is automatically turned in the position shown, thus causing the torpedo to be steered around toward the enemy. When the torpedo is headed for the enemy and consequently both microphones are equally energized, the rudder assumes a midship position.*

How the Leon Torpedo Hears an Enemy's Propellers and Directs Its Course Accordingly.

THE *straight dotted line represents the intended course of the torpedo as it was dispatched originally against the enemy. The enemy has passed beyond the path of the torpedo; but, thanks to its microphones or ears, the torpedo alters its course as shown by the dotted line and overtakes the enemy in its new position on a curved path.*

ing is much less dangerous than is commonly supposed.

Because battle ranges are now so great that the gyroscope cannot be expected to keep up its spin for a corresponding period, we find Nikola Tesla, Rear Admiral Bradley A. Fiske and John Hays Hammond, Jr., trying to control torpedoes by wireless. But a much more startling plan than theirs is that of Captain Karl O. Leon of the Swedish Navy. He would have an enemy's ship destroy itself by attracting a torpedo to its very side.

His invention consists in giving a torpedo ears—electrical ears which will enable it to hear the propellers of a ship and direct itself toward the sound. Only a ship at anchor would be safe; for in the murkiest weather or the darkest night his torpedo will hear the propeller vibrations and head for them.

The Electrical "Ears" and How They Hear

Captain Leon's electrical ears are microphones. A microphone is found in every telephone transmitter. It is an instrument for intensifying feeble sounds or for transmitting sounds, and it is based on the principle that the transition between loosely joined electric conductors decreases in proportion as they are pressed together. The conductors form part of a circuit through which a current is passing, and the variations in pressure due to sound waves in the vicinity of the conductors produce variations of resistance, and hence fluctuations of the current, so that the sounds are reproduced in a telephone receiver. In the modern telephone the transmitter is essentially a microphone, the pressure of the sound waves being communicated to the conductors by means of a diaphragm.

Captain Leon mounts four of these sensitive electrical ears on a torpedo. When they are influenced by the sounds of the enemy's screws they automatically steer the torpedo, not at the direct source of sound (the propellers), but several yards to the right or left, according to the direction in which the hostile ship is traveling. The four sensitive ears are in the head of the torpedo and point forward. Two of them are located on the horizontal center line and two on the vertical. The right and left microphones on the horizontal center line control the horizontal steering rod

The Shonnard Torpedo—

THIS *drawing shows schematically the application of the Leon steering device to a modern long-range high-speed alcohol propelled submarine torpedo invented by H. W. Shonnard. In the fore part of the torpedo head can be seen the starboard microphone receiver. In the upper part of the head is located a box in which the adjusting mechanism is contained, the purpose of which is so to regulate the microphone as to cause the weapon to strike either to the right or to the left of the source of sound. An electric cable extends from this controlling box through the air flask to the gyroscopic gear located in the after body. The gyroscopic gear is connected with the rudders as described in the article and diagrammatically shown on page 28*

The Shonnard torpedo is perhaps the most promising type of internal combustion propelled torpedo which has yet appeared upon the horizon of American practice, and it is here illustrated in conjunction with the Leon microphone steering device because of its extreme novelty of design. It will be noted that the propellers are driven by three horizontal engines, one of the cylinders being located above and two below the center line of the torpedo, thus ensuring stability and providing a very compact and powerful motor. Around the engine is an enclosed space in which the liquid fuel (alcohol) is carried.

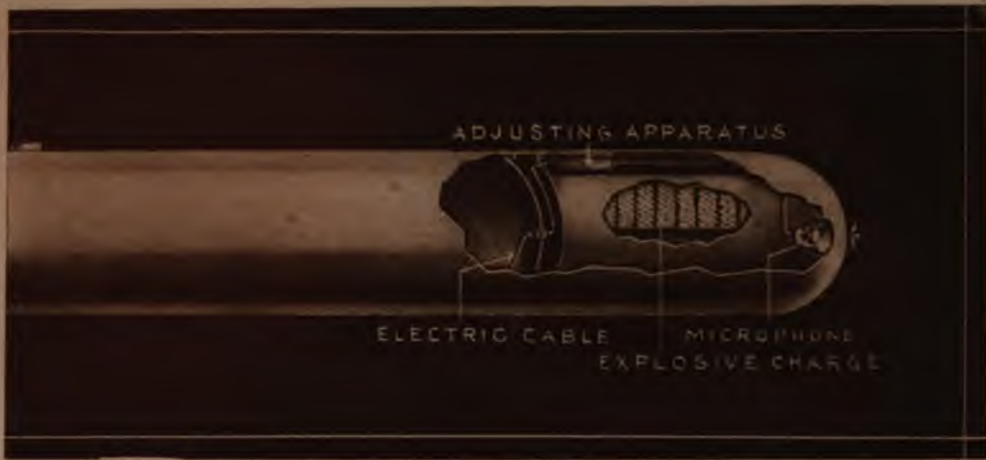
ders, and the upper and lower microphones on the vertical line control the depth steering mechanism.

Preventing the Torpedo from Blowing Up Its Own Ship

Captain Leon also employs a gyroscope, but it serves to guide the torpedo only for a short distance. As soon as the electrical ears hear the propellers the gyroscope is thrown out of action automatically and the ears left to themselves. Of course, the vessel which fires the torpedo also has propellers. It is very important that the torpedo shall not hear them, turn back on its course and blow up its own ship. For that reason a suitable clockwork time switch is introduced which keeps the sound apparatus from operating until the torpedo has proceeded a considerable distance on its deadly errand.

If the Leon torpedo is correctly pointed toward the enemy, an equal amount of sound reaches each one of the microphones or ears; but if, for instance, the weapon is traveling too far to the right or to the left the effect on one ear is greater than it is on the other. Consequently, the rudder is caused to shift and the torpedo's course is altered until the microphones are all equally influenced by the vibrations set up in the water. After that the torpedo proceeds head on.

Sound travels much more quickly and clearly in water than it does in air. That is one reason why the propellers of a large battleship will set up a disturbance



The Latest Fashion in Torpedoes

Compressed air from the air flask passes through a reducing valve and is delivered to the engine at a uniform pressure. The liquid fuel is maintained under pressure derived from the air flask and is delivered to the mixing chamber.

The propeller shafts are tubular and are telescoped one within the other. They are revolved in opposite directions by a group of three gears directly driven by the engines. An extension on the end of the main propeller shaft revolves within a casing and performs the function of a rotary valve, the head of which forms one-half of the mixing chamber. The ignition system has, of course, the usual spark plug and magneto.

From an oil flask oil is delivered under pressure to the valve chamber, where it serves the double purpose of lubricating and preventing leaks.

When the starting latch on top of the torpedo is tripped, which happens when the torpedo is launched, compressed air is admitted to the engine in order to start it. At the proper instant a suitable charge of alcohol is sprayed into the mixing valve and exploded into the cylinder. Shonnard employs a tank of compressed air so as to relieve the engine of the necessity of compressing the charge in the manner familiar to every automobilist.

in the water which would influence delicate microphonic receivers over a very great distance. Even though the torpedo may be several thousand yards out of its course, it must inevitably be drawn toward its prey.

The Ultra-Range Gyroscope and Its Possibilities

Originally Capt. Leon did not include a gyroscopic steering gear, but depended solely upon the sound-receiving microphones for steering. This arrangement is unsatisfactory except for very short distances, because the weapon is liable to make a large detour before the sound apparatus comes into play. The introduction of the gyroscope was a decided improvement and greatly increased the efficiency of the weapon.

By using the ultra-range gyroscope invented by the author it is possible to increase the efficiency of the Leon torpedo almost 100 per cent. The extreme accuracy which is made possible by this new form of gyroscope greatly reduces the demands made upon the sound receiving apparatus. In actual practice it is necessary to employ only two sound receivers, one on the right side and one on the left, in order to maintain a horizontally steered course.

Guiding the Torpedo by Means of an Echo

The Leon torpedo, it has been pointed out, is effective only against a moving ship. Why not send out a call from the torpedo and let the ear be guided by the

echo. In order to make the torpedo effective even against an anchored vessel, the author has conducted experiments which lead him to believe that an oscillator or sound producer may be inserted in the nose of the torpedo for the purpose of sending out sound vibrations which may be reflected by an anchored ship. There is good reason to believe that the effect of the reflected sound is practically the same as that of the direct vibrations, except that over great distances they are somewhat enfeebled. But the results thus far obtained are encouraging to such an extent that it will ultimately be possible to use the Leon torpedo even when a ship's propellers are not working.


The torpedo tube of an American submarine boat. The pivoted lid is opened at the moment the torpedo is to be ejected.

Capt. Leon is not the only inventor who has been working in this field. Christian Berger of Hungary and John Gardner of England have independently suggested the use of microphones on a torpedo. It was their idea to place one or more microphones on a torpedo. But instead of picking up sounds emanating from a hostile vessel, they intended to send out submarine signals from a controlling station, by means of which the course of the torpedo could be governed. To this there is the manifest objection that the vessel must be seen to be guided. Although it is not necessary to provide the torpedo with high masts easily shot away (one of the difficulties of wireless control), it is nevertheless necessary to watch the course of the torpedo while it speeds toward the enemy.

THE LIGHTNING ROD COMES BACK

After a number of years of increasing unpopularity, the lightning rod is rapidly reappearing on the roofs of houses and barns throughout the country. The statement made a great many years ago by those who were supposed to know, that lightning rods not only were ineffective as lightning preventives, but that they actually attracted lightning, has been proved to be absolutely false by an extensive series of tests made by the United States Weather Bureau. Circular letters were mailed to mutual insurance companies throughout the country, especially to those in the agricultural districts, requesting statistics concerning the fire losses of insured buildings occasioned by lightning in comparison with losses due to other causes, and particularly the fire losses occurring to buildings equipped and unequipped with lightning rods. The replies gave strong evidence of the value of the rods. In 1912 and 1913 about 200 mutual insurance companies doing a business of fully $300,000,000 had 1,845 buildings struck by lightning. Of this number only 67 were equipped with lightning rods. So far as could be learned about 31 per cent of the buildings insured by these companies were rodded; hence, if the rods had furnished no protection, buildings struck would have numbered 572 instead of 67. Thus the efficiency of the rods in actually preventing lightning strokes appears to have been fully 90 per cent.

Making Artificial Eyes for Blinded Soldiers

The Artificial Eye Maker First Takes a Tube of Glass, Heats It and Blows It Until a Bubble of Glass Is Formed at the End. The End of the Bubble Is Then Perforated With a Conical Point As Here Shown. Thus the White of the Artificial Eye Is Formed. The Iris Appropriately Striated, Is Then Fused to This Bubble

Blowing a Bubble of Glass. After the Iris Is Made It Is Soldered to the End of the Sclerotic, or the Imitation White of the Eye Which Encloses the Eye Ball. The Whole Is Then Tinted in Exact Similitude to the Natural Eye

The Fatal Hum of the Submarine

By William Dubilier

The author of this article is an American electrical engineer, who went to Europe, at the invitation of one of the Allies, to devise a system of harbor defense against hostile submarines. Thanks to his work, it is now impossible even for a submarine traveling under water to enter an English or French harbor without being detected. His interesting article describes the experiments which led to the adoption of a remarkable microphone submarine detector.—EDITOR.

LET a submarine dive below the surface of the sea and it would seem utterly impossible to locate her. No eye can see her. If she plows along at a depth not greater than a hundred feet she can be seen in clear water from an aeroplane. But if she descends below that she is as invisible as any fish.

Suppose that a submarine gave forth a sound of some kind, would it not be possible to devise some form of apparatus by which it could be heard? That was the starting idea of the experiments that I conducted for the allied Governments. It is not a new idea. Professor Tissot was hard at work with the original experiments and had already used microphones for this purpose. Professor Fessenden had made some brilliantly successful experiments with an apparatus of his invention, known as an "oscillator," which showed how easy it is to locate a steamship in a fog or at night, provided that it sent forth sound waves. Tests of his instrument had also been made on submarines.

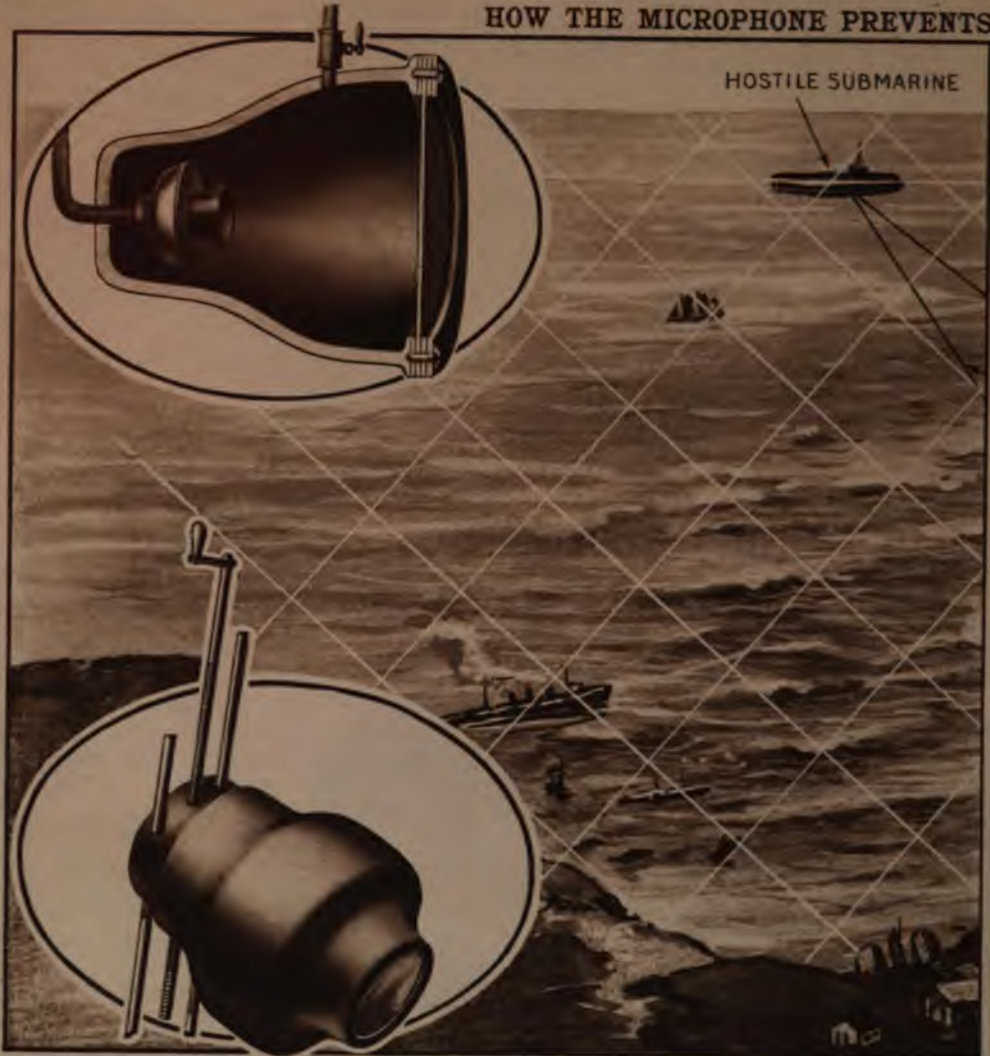
But these investigations were all conducted with a device which was installed for the deliberate purpose of making a rhythmic noise to be detected. What was needed was some form of apparatus which would pick up the sounds sent forth by a submarine, not deliberately, but involuntarily.

Mr. Dubilier holding in his hand one of the small microphones which he used in his experiments

Strange Noises of the Sea

At once the beating of the propellers of a submarine suggests itself. It is not characteristic enough. Motor boats, steamships, and other power driven vessels have propellers, and although their period of vibration is different from that of any other engine-driven craft, some other sound must be sought—something as distinctive as the call of a robin or the neighing of a horse, something that by no possible chance can be mistaken for another sound.

I found what I sought in the weird, shrill hum of a submarine. Others had heard that hum long before I began my experiments. It was taken for engine vibration. But it is much too high in pitch for that, as I found by actual tests. A ship's engines pound out vibrations not greater in frequency than fifteen a second. You can almost count the beats. A propeller has a period much higher, but not high enough to produce the unmistakable insect-like droning that comes from a submarine under the



The harbors of France and England are mapped out in imaginary squares, each bearing a number. In two stations, A and B, located a measured distance apart, microphone detectors are located. The stations A and B are in telephone communication with the wireless station C. The officer in station A adjusts his microphone until he hears the hum of the submarine most plainly; the officer in station B does the same. Imaginary lines drawn perpendicularly to the microphone diaphragms will meet at the exact spot where the submarine is to be found. The necessary calculation is performed in the station C, for the officer there in charge knows the exact distance between A and B and the angles

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(Upper Left-Hand Oval Insert:) First experimental microphone and container. This form of electrical ear heard too much because it was influenced by passing steamers as well as submarines. The hum of the submarine was drowned out by the pounding of steamer engines and the beating of propellers

(Lower Left-Hand Oval Insert:) The microphone and containers were suspended as shown. A threaded rod, with a handle at the end, passed through a central hole. Two outer holes slid over guide rods. It was possible to screw the microphone up or down or to throw it bodily from side to side until the hum of the submarine was heard most plainly

(Upper Right-Hand Oval Insert:) In the upper right-hand oval picture a system is shown which was experimented with in order to eliminate all sounds but the hum of the submarine. This involved the use of a contact maker and breaker which made and broke the circuit with the same frequency as that of the submarine's hum. There was only one

made with the base line A-B by the imaginary lines running to the submarine. A very quick calculation enables him to determine exactly in what square the submarine is to be found. He sends a wireless dispatch to a torpedo boat to proceed at once to square 23 or 25, as the case may be. As the submarine moves, its direction is telephoned by the officers in stations A and B to the officer in station C. By wireless, the officer at C directs the course of the torpedo boat so that it follows the changing direction of the invisible enemy. Unless the submarine drops to the bottom and stops its motors, it must be inevitably caught when it rises to the surface

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circuit at first—a battery, a microphone and a receiver. If a contact breaker were put into this circuit, naturally a continuous noise would be produced, due to the rhythmic breaking of the circuit. By inserting a transformer and placing the contact breaker in the secondary circuit, this difficulty was immediately eliminated. In technical parlance, the contact breaker was of such a type that the phase could be shifted so that the waves would be broken at the crest. The system was fairly successful, but not altogether trustworthy. It eliminated extraneous noises, but sometimes it also eliminated the very submarine hum which the experimenters most wanted to hear

(Lower Right-Hand Oval Insert:) Eventually, a telescoping resonating tube was adopted, which was attached to the diaphragm, and which, being attuned to the hum of the submarine alone, excluded all extraneous sounds, such as the vibration of engines of passing ships and the beating of propellers

surface of the water The period of vibration is about seven hundred and fifty a second. To produce a hum so high in pitch a propeller would have to revolve at a speed much greater than we dare to give to the flywheels of steam engines.

The Hum of a Power House is Identical With That of a Submarine

I soon convinced myself that the fine, shrill, almost singing note that can be heard when the Diesel engines are cut off and the submarine is traveling under power derived from her storage batteries is due entirely to her electric motors. The sound is unmistakable. Step into any central station where electric power is generated to light a city and you will hear the hum of a submarine. There is no difference to the ear. To devise a means of detecting this sound at great distances was the object of my experimenting.

The microphone at once suggested itself as a suitable instrument.

In my first attempts to detect submarines by their characteristic hum, the microphone was sealed within a watertight container and the whole placed in the water. The apparatus was a failure. It could not withstand the pressure of water even at five fathoms. The container was crushed like putty in a strong hand. Since the depth at which the microphone was expected to work might reach forty fathoms, where the pressure was hundreds of pounds to the square inch, it was obvious that some method of resisting the water had to be devised. The container had a diaphragm on one side, against which the sound waves from the submarine impinged. Because of the water pressure the diaphragm could not vibrate freely, and hence the microphone was highly inefficient.

Ears That Heard Too Much

In order that the diaphragm might successfully resist the external pressure air was forced into the container until its pressure equalled that of the water. The new form of apparatus was much more successful than that first used. Submarines could be heard beneath the water at a distance of five miles, and the apparatus stood up well, even at great depths. But it had the great defect of hearing too much. Not only was the hum of a submarine picked up with astonishing clearness, but other strange sounds of the sea as well—the vibration of engines in passing steamers, the beating of propellers in water. A steamer sets the water vibrating with an intensity thousands of times greater than that of a humming submarine. In that deluge of sound the submarine could not be easily detected. It was like trying to hear the thin, clear note of a violin under a railway trestle while a train was passing overhead. A kindred phenomenon is observed in radio stations. The wireless operator calls it "static." He eliminates static by tuning his apparatus to respond only to the signal that he wishes to detect.

In order to make the microphone effective an analogous system of mechanical tuning was invented. It was necessary to eliminate all sounds but that emanating from the submarine to be located. You can understand how that is possible if you have noted the response of a piano to a violin. Draw your bow over any of the violin strings and sound a single clear note, and you will hear a faint response from the corresponding string in the piano. Of all the strings in the piano only that one answered the violin. Why? Because that was the only string in tune with the violin note.

The Invention of a Sound Sieve

Clearly, some kind of sound sieve was wanted—something that would sift out everything but the singing submarine.

Years ago an instrument maker, named Koenig, at the University of Paris, devised an adjustable resonator. It consisted merely of two telescoping metal cylinders. The cylinders were closed at one end except for a sound opening. If you wanted the cylinders to sing in unison with a vibrating tuning fork, you could do so by moving the cylinders upon each other. A point would be reached at which the natural period of vibration of the air space within the cylinders was exactly equal to that of the tuning fork, with the result that the resonating cylinders gave forth the same note as the tuning fork. While the cylinders were thus adjusted they would respond to no other

note. Still, they could be made to sing in unison with any other tuning fork merely by adjusting the telescoping cylinders.

Playing a Flute to Analyze the Hum of a Submarine

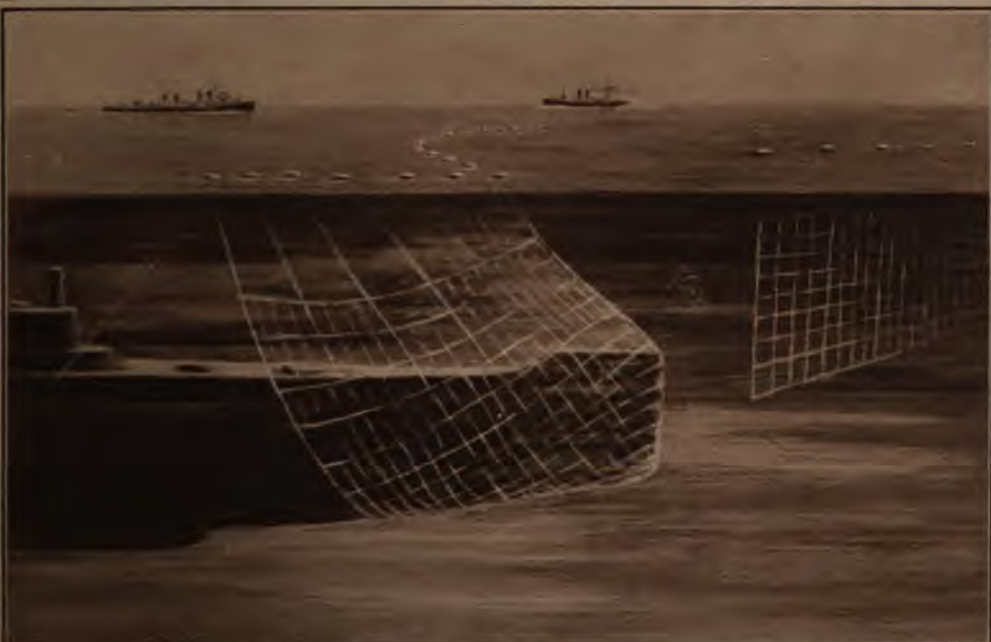
It was this principle which was applied in the construction of a microphone which would respond to nothing but the singing electric motors of a submerged submarine. In front of the diaphragm of the microphone-container a telescoping tube was secured. To ascertain the natural frequency of vibration of a submarine's electrical machinery a flute was played. It was found that a note could be extracted from the flute which corresponded exactly with that emitted by the submarine. Experiments were then made with the flute in front of the resonating diaphragm tube. By pushing the tube in and pulling it out it was finally adjusted so that it sang with that note of the flute which corresponded with the hum of the submarine.

The result was startling. The microphone now responded to nothing but the humming submarine. Ocean steamers with great pounding engines within them passed unheard. Only the high-pitched note of the submarine reached the ear. A French submarine and a torpedo boat destroyer were placed at my disposal for experimental purposes. The sounds from the two never clashed; the submarine alone was heard.

Other forms of sound receivers were tested, and we finally adopted one which gave most satisfactory results. In front of the resonator tube a diaphragm was mounted, and to this a second resonating tube was attached. The double-tube resonator was placed within a heavy casting provided with a diaphragm, and into this container compressed air was pumped to offset the water pressure. One of the inserts on the double-page illustration shows the construction so that further explanation is unnecessary.

The Electrical Ear and How It Hears

This microphone, or electrical ear, as it may well be called, proved to be extraordinarily sensitive. It could detect a submarine twenty miles away. And it behaved curiously like a telephone. Talk squarely into a telephone transmitter and



The English Channel is a labyrinth of nets. They are suspended from floats. When the floats are straight, the English patrols know that nothing of moment has happened below the surface; but when they are askew, as in this picture, they know that a submarine has been caught

the man at the receiver will hear you clearly; talk into the transmitter sidewise, and you will be heard less distinctly. So it proved with the microphone. When the singing note sent out by a submarine under water struck the microphone squarely it was heard much more distinctly than if the microphone were inclined to the sound waves. That made it easy to note in which direction the submarine was traveling. The microphone had merely to be turned until the hum was heard most distinctly.

To determine the exact spot where a hostile submarine might be at any given moment two microphones were employed. Imagine two stations, *A* and *B*, along a coast line; imagine a microphone detector in each, and imagine a central station, *C*, the headquarters of a naval officer in telephonic communication with stations *A* and *B*. The microphone detectors at stations *A* and *B* are turned from side to side until the submarine is heard with the greatest distinctness. Imaginary lines drawn perpendicularly from the microphones would meet at the point where the submarine is to be found, and the length of the line can easily be calculated by a simple trigonometrical process.

For the purposes of defense the harbors of the world are usually ruled off by artillery officers into imaginary squares, which are plotted on a map. Suppose that a submarine is in square 23. The officer in the central station *C* is told by the microphone operators in stations *A* and *B* the exact inclination of their instruments at the moment. He carries out a rapid trigonometrical calculation, and the result shows him that the submarine must have been in square 23 at the time his data were telephoned to him. At once he sends out either a fast motor boat, armed with a gun, or a torpedo boat destroyer, to square 23.

Tracing the Course of an Invisible Submerged Submarine

But, you naturally object, the submarine under water is not at rest. It is moving at the rate of ten knots. By the time its pursuer reaches square 23 it may be in square 35.

The objection is very easily met by wireless. As soon as the pursuing boat starts for its prey its wireless operator

Below the surface of the water a submarine is sightless, for the periscopes have been withdrawn. The British have taken advantage of this. Railway rails are suspended from a raft, as here shown. If a blind submarine collides with them, its shell is crushed in. Death and destruction inevitably follow

listens for signals from the central station C on shore. The men in stations A and B follow the moving submarine with catlike vigilance, each second. They turn their instruments this way and that, always listening, until the sound that comes to them is clearest. They telephone from minute to minute to the central station. "Heading north east" is the word from station A. "Heading north northwest," telephones the man at station B. And so, the course of the invisible terror beneath the waves is constantly followed with an accuracy that must seem as uncanny as it is simple.

The Blind, Helpless Submarine

The captain of a hostile submarine has no means of knowing that he is pursued when he is submerged. He is absolutely blind. His periscope avails him not. Sooner or later he will rise to the surface, like a whale, if not to blow, at least to see. Certain destruction awaits him. The instant his periscope juts out of the water a hail of bullets rains upon his deck. His enemy rushes upon him, rams him and crushes in the thin shell of his submarine like paper.

The experiments here described resulted in a complete defense against submarines lurking in harbors and waiting for a chance to torpedo a vessel about to put out to sea.

Obviously the same principles can be used on shipboard. I have myself conducted experiments along lines indicated by Professor Tissot and Professor Fessenden with encouraging results, and I know that microphone detectors are now used on English ships to pursue as well as to avoid German submarines.

If the Germans practically have abandoned submarine warfare, it is not only because the volume of British shipping is so enormous that a hundred submarines could not hope to wipe it out completely, but also because the microphone has been able to ferret out underwater craft even when submerged at great depth.

The first American linotype machine has recently arrived at Tripoli.

Wireless Tower Wrecked by a Gale Stops a Train

During a terrific gale last fall the new three hundred and four foot wireless tower at Tufts College, Massachusetts, was blown over and a section dropped thirty feet in front of an express train speeding to Boston. The quick wit of the engineer in throwing on the brakes and reversing the throttle prevented a very serious accident.

The tower carried away telephone and telegraph wires and also blocked a main arm of the railroad for several hours.

The steel structure was to have been the highest wireless mast in New England, the foundation being ninety-six feet above sea level, making possible radio connection with Europe. An umbrella antenna was planned to radiate from the top, but had not been installed at the time of the accident.

The wireless tower, wrecked by a gale of wind, lay on the ground twisted like a snake

The tower of the Tufts Wireless Station fell directly across a railway track

This was the only tower of its kind in the country and the height was to have been increased to five hundred feet. Guy wires supported the tower at every one hundred feet, but were not sufficient to support it adequately against a high wind. The hollow steel structure was about six feet square from top to base.

During 1914 the marketed production of natural asphalt in this country was 77,588 short tons, with a value of $630,-623.

How Blotting Paper Absorbs Ink

EVERY student of physics knows that water will run up a narrow tube by capillary attraction. Anything immersed in water has a similar attraction for the water; that is, the object becomes wet by the water that clings to it. The amount is limited by the weight of the liquid itself. Place your hand in water, and your hand, when withdrawn, is wet. The limited attraction between the hand and the water is gaged by the weight of the water that clings to the hand.

Blotting paper absorbs ink on the same principle as a handful of hay will absorb a liquid

Imagine several hands placed close together in water, but not touching one another. If this composite hand were formed of ten single hands, it would attract ten times as much water as the one hand would attract and hold on its surface. So, a wisp of hay, composed of a hundred spears of dried grass, placed in water, will remove a hundred times as much of the fluid as would cling to one spear. Bushes in a marsh will remove a certain amount of water which will, by capillary attraction, cling to their submerged parts.

Under the microscope, fibrous blotting paper, when absorbing ink, resembles, on a small scale, a marsh matted with shrubs and sticks and twigs, around which water is flowing as ink runs about and among the fibers that together form the spongy paper. There is a limit to the amount of liquid which a "blotter" will absorb, as there is a limit to the amount of water that a marsh will absorb without overflowing. That limit, in the "blotter," is the combined capillary attraction of the fibrous shrubs and sticks and twigs that together form the paper.

Balsa, Lightest of Woods

EXPERIMENTS made by the Missouri Botanical Garden of St. Louis show that the wood called balsa, native to the West Indies and Central America, is nearly twice as light as cork.

In the photograph a piece of balsa-wood (B) is balancing a piece of Australian ironbark (A). The two blocks have the same width and thickness, but *B* is ten times the length of *A*.

Balsa is very soft. It is easily cut with tools, and is imported into the United States from Costa Rica to make the floating parts of life-preservers and life-rafts. The government uses it for buoys and water signals. It has several advantages over cork.

Balsa, on the right, is a wood ten times as light as ironbark, on the left

Why Does a Rifle Crack?

By Edward C. Crossman

A WAR strength infantry company lay in our rear. We walked toward its far-off target, nearly in the line the bullets would take, a few yards' divergence to the left giving us the safety margin we felt would be enough with such expert marksmen. From some indefinite point in the air to our right, there came a sudden burst of high, thin, eerie crashes, the thin crash that comes from the leap of the electric spark from the static machine, repeated in fitful fashion. Most extraordinarily, the sound lacked any definite point of origin; it seemed higher than we were; and it seemed to come from our right. Nearer than this we could not locate it. A slight lull in the sharp crackling, and there came another sound—the heavy, dull thudding of guns fired at a great distance. As we progressed toward the long fire target twelve hundred yards from the infantry, the queer crackling noise followed us, growing thinner and more weird, but the thudding of the far distant guns grew fainter.

Photograph by Ordnance Department, U. S. N.

The bullet was photographed when six inches from the muzzle, just escaping from the blast gases of the rifle. Note the outline of the sound wave diverging from the nose of the bullet. This is the first stage of the exit of a bullet from a rifle's muzzle. It is not unlike the bow wave of a boat

Photograph by Ordnance Department, U. S. N.

This picture was taken when the bullet was eight inches from the muzzle, and traveling at a speed of roughly a half-mile a second. The two wires making the contact and the electric flash by which the photographs were made are shown as two black lines. The bullet takes its own picture. Note the eddying effect of the air behind the bullet. The fastest mechanical shutter, giving an exposure of one-thousandth of a second, would allow the bullet to move 2.7 feet during the opening of the lens

We were walking not more than one hundred or one hundred and fifty yards from the line of fire of a trained infantry company, delivering its fire at a group-target twelve hundred yards, roughly three-quarters of a mile, away.

The thin, high-pitched crackling, that seemed at one time like the leap of the high-tension spark of the static machine, at another like the cracking of whips, and again like the vicious crash of a stone through glass, came from the flying bullets of the United States service rifle, which starts with the speed of twenty-seven hundred feet per second. The thudding, that fell off to almost nothing at twelve hundred yards, came from the rifles themselves, the only sound one hears when close to them, but the least noticeable at a distance when one is close to the course of the bullet.

As we gained the target, a new sound

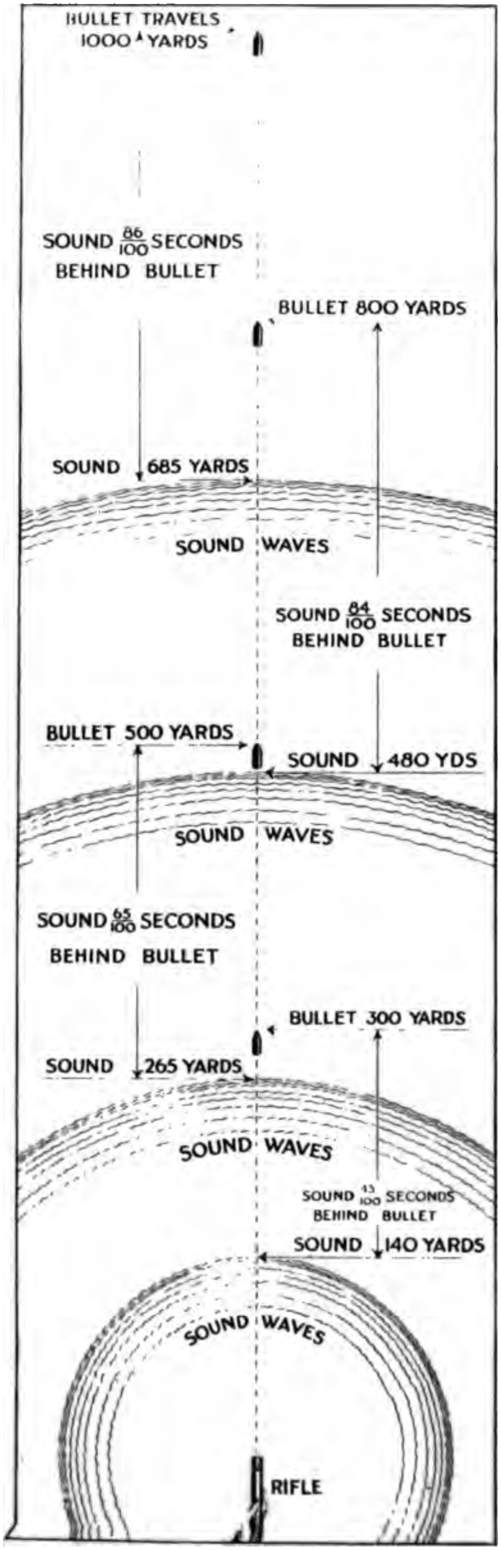
mingled with the irregular crashing of the bullets—a high-pitched whine, with an occasional vicious yowl punctuating the noise. This came from the ricochetting bullets, striking the ground short of the target and then glancing off and pursuing their erratic course through the air, their velocity much diminished, their travel changed to an end-over-end whirl, and the bullets themselves defaced and battered by the impact with the ground.

Back of the target the bullets passing through it went into the waters of the lake several hundred yards out, with the noise of heavy blows, almost as hollow and heavy as the impact of a well-swung carpet beater on a huge, loose carpet. Almost the same sound comes when a bullet strikes flesh, human or otherwise.

Normally the sound of the progress of the modern military bullet up to nearly a mile, is the high-pitched, ear-splitting vicious crash. At longer ranges it hums, probably from an increasingly unsteady flight. Or possibly it hums all the time, but the sound is killed by the vicious crash that accompanies the bullet while it is traveling fast.

Under some conditions of air and background, not yet clear to me, bullets hiss. The sound is noticeable at the skirmish, on the six hundred yard range at Camp Perry, and at the great matches. It is never heard at the range of the writer's club, situated in the hills with every chance for sound to be echoed back and reproduced, nor has the writer heard it on any other range. However, this hissing noise is audible only at the firing point. Trial out along the flight of the bullets developed that either they did not hiss to the person so located or else the hiss was covered up by the usual crash, which amounts to the same thing in the end.

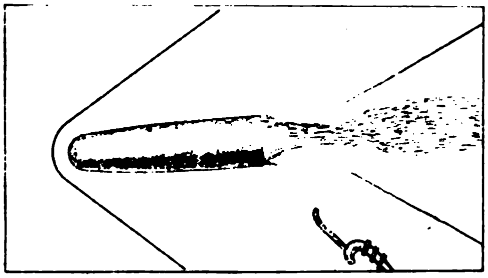
Never do bullets howl unless they have been tipped out of normal flight by striking some obstacle. The howl is merely the noise of a more or less jagged missile whirling end-over-end, while the normal bullet, traveling nor-



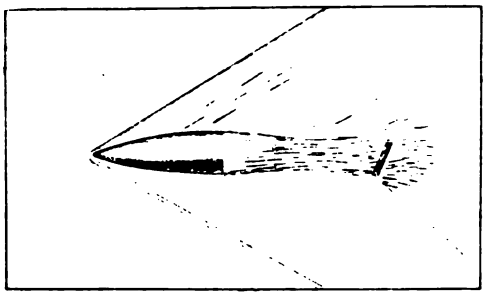
Sound is slower than a bullet. Bullet crash and rifle report are heard one after the other. The crash is due to air rushing in to fill the vacuum behind the bullet

mally, slips through the air like a trout through water.

The soldier, fired on and missed by a single sniper without other sound to confuse or cover up that pertaining to him, hears two distinct sounds, if the firing takes place within four hundred yards or so. Phonetically they are "Pack-punk." The first is a vicious and menacing crash. It is the bullet arriving with its regards to him; the second is the report of the rifle which follows along some distance behind the bullet. The modern bullet travels faster than does sound, which has but the speed of eleven hundred feet per second. The person watching the jet of steam from the whistle of the far-off locomotive and noting the interval of time which elapses before the whoop of the whistle arrives, will appreciate that sound is a leisurely traveler.



Drawings from photographs of bullets in flight. Showing older type, metal jacketed, small bore military bullet in flight. Note bow wave of air driven ahead of the bullet, and the eddies of air in the wake like water in the wake of a ship. Directly in rear of the base of the bullet is the vacuum that causes the sharp crash as the air closes suddenly in upon it

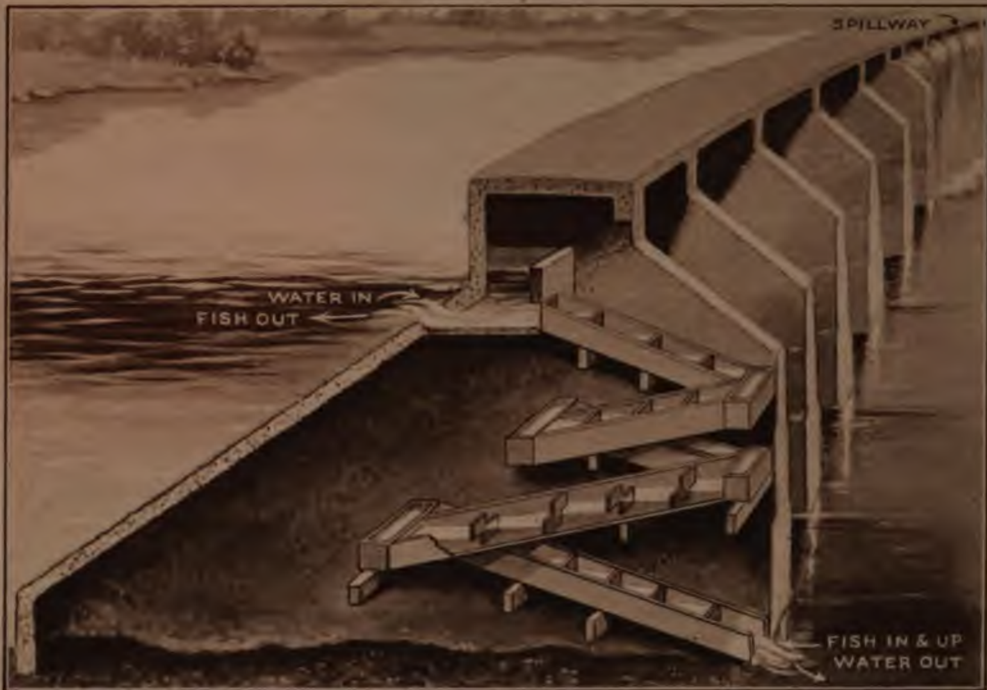


The flight of the modern spitzer bullet, which is used by Germany, England, France, the United States and some other nations. Note the sharper angle of the bow wave, and the greater vacuum in the rear of the bullet. This is caused by the fact that these lighter sharp-point bullets are driven at far higher velocity than the older type, and the vacuum is more pronounced. Also the noise is more marked. A bullet which tapered down to the stern as sharply as the point of the bow would have little vacuum and little noise. The photograph from which this sketch was prepared was made by Professor Boys by means of an electric spark produced as the bullet cut the wire

The crash comes from a vacuum formed in the rear of the flying bullet by its enormously quick displacement of air. The bad shape of the missile allows the air to flow back again around the stern, like water around the stern of the fast moving boat. Finally, the air rushes in behind the bullet and makes the crash just as the air rushes in behind the electric spark.

Only at speeds higher than twelve hundred or fourteen hundred feet per second is this sound heard. Strangely enough it is not heard if the bullet has started at very high speed and falls to this lower one. Possibly what is heard in such case is the crash of the bullet at some distance farther back where the velocity is still high enough to produce a crash.

Military rifles drive their bullets at speeds of from two thousand to three thousand feet per second. The same bullets, loaded to give velocities of less than fourteen hundred feet per second, do not make a sound. So, black-powder or low-power rifles like the familiar .22, do not produce this crash from their bullets. The difference in the arriving time of the two sounds, bullet crash and report of the rifle which fired it, is very noticeable at the long ranges. At one thousand yards, for instance, the bullet of the United States rifle arrives at the mark 1.86 seconds after it leaves the muzzle of the rifle. The bullet thus covers the distance at the average speed of about sixteen hundred feet per second. Sound, traveling at the uniform rate of eleven hundred feet per second, takes 2.7 seconds to make the trip, and the bullet and its accompanying crash, thus arrive nearly a second ahead of the report of the rifle. So comes about the phenomenon of the two distinct sounds: first the bullet and then the report of the rifle.



The Water in the Ladder is Continually Flowing Down and Out, Forming a Running Stream up Which the Fish May Swim, Jumping from One Pool to the Next Higher One

How Fish Jump 100-Foot Dams

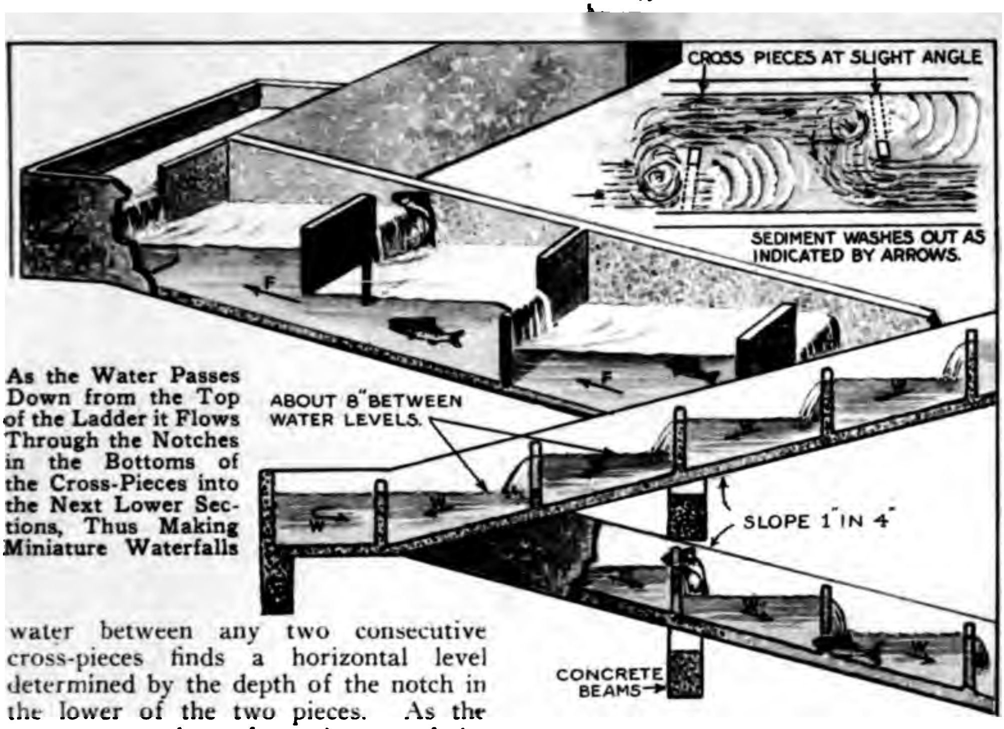
DO you know that fish actually jump one hundred-foot dams in their migrations each spring to the headwaters of the rivers in which they spawn? Of course, this one hundred-foot jump is not made all in one leap, but in a number of short leaps of eight inches each. This feat is made possible by what is called a fish ladder.

This ladder must be placed in all river dams in which fish such as salmon swim up to the river heads to spawn. Fish will not spawn anywhere except in the still headwaters, and it is necessary that they arrive there with the least exertion. The government makes it obligatory that at least one fish ladder be built into every dam across such rivers.

Fish ladders, while they may be built of wood, stone or concrete, according to the material of which the dam is constructed, are all alike in principle and consist of a trough which begins at water level on the low side of the dam and then extends upward in several zig-zag steps to a point below the water level on the up-side of the stream. Water enters at the top end and flows down and out at the bottom. Its flow, however, is not free like that in a sluice, but is retarded by means of cross-pieces at regular intervals in the trough.

The accompanying illustrations show a reinforced concrete fish ladder built in the most modern type of dam of concrete construction. The cross-pieces are also made of concrete and form small pools of water between consecutive pieces. Each cross-piece is set at a slight angle to the sides of the trough, alternate ones being slanted in opposite directions. Each piece has a rectangular notch cut in the top and another in the bottom on the opposite side.

Alternate pieces have the two notches placed on opposite sides, respectively, as shown in the detailed perspective drawing. The trough being inclined, the



As the Water Passes Down from the Top of the Ladder it Flows Through the Notches in the Bottoms of the Cross-Pieces into the Next Lower Sections, Thus Making Miniature Waterfalls

water between any two consecutive cross-pieces finds a horizontal level determined by the depth of the notch in the lower of the two pieces. As the water passes down from the top of the ladder it flows through the notches in the bottoms of the cross-pieces and also drops over the top notches in the cross-pieces into the next lower sections like small waterfalls.

The water in the ladder is continually flowing down and out at the bottom, forming a running stream up which the fish may swim with a choice of passing from the first pool to the next and so on up by swimming through the bottom notches or jumping through the top notches from one pool to the next higher one. The jump in the latter case is not more than eight inches and can be done easily by almost any kind of fish.

It is noted in the plan view of the ladder shown in the accompanying drawings that the notches in the bottom of the cross partitions are placed at the lower end of the partitions to permit any sediment to be washed out by the flow of water. In the large drawing it is also to be noted that the ladder is not placed in close proximity to the spillway. The reason for this is that fish in trying to ascend a dam seek to pass up the largest stream of running water. Due to the fact that the volume of running water issuing from the ladder is usually less than that dropping over the spillway the fish would not find the ladder readily if it were close to the spillway but would try to swim up the spillway and would probably dash themselves to death against the concrete buttresses.

Borrowing the Night Lamps of the Fireflies

Just what the secret of the firefly's light is the scientists have not as yet discovered. Three necessary factors have been found—water, oxygen and a photogenic or light-producing substance; but a fourth is probably involved which has thus far defied all research. The children say it is the fairy lamplighter whose wand lights the little lamps that adds so much to the beauty of a summer's night. However, a method has been evolved of extracting and drying the light-producing organs of the firefly without impairing the power of the substance to phosphoresce.

The dried material may be extracted with water-free solvents. It is ground up into a powder, and water containing oxygen is added; which gives the golden glow without the assistance of either the firefly's will or the fairy's wand

"F-4" IN PORT—A SUBMARINE COFFIN FILLED WITH DEAD

How the "F-4," suspended from six pontoons, was towed into Honolulu. This was one of the saddest funeral processions that the port ever saw. Fifteen met death in the engine-room, where they sought refuge at the last; six died at their posts in the flooded forward compartment. The disaster was caused by a leak resulting from a corroded battery lining and corroded rivets, and the failure of the boat, through poor diving qualities, to respond promptly to a rudder change which should have brought her to the surface.

How the Submarine "F-4" Was Lifted Out of Three Hundred Feet of Water

By Lieutenant-Commander Julius Augustus Furer,
Naval Constructor, U. S. N.

Lieutenant-Commander Furer, the author of this article, planned and directed the raising of the "F-4" in all its phases. Therefore, his highly interesting and simple exposition of the engineering methods employed may be regarded as trustworthy in every particular. A Board of Inquiry, headed by Rear Admiral Busch, attributes the disaster to a leak, resulting from a corroded battery lining and corroded rivets, and to the failure of the boat, through poor diving qualities, to respond promptly to a tilting of her rudder, which should have returned her to the surface. The "F-4" was a fairly new submarine, having been accepted by the Government on May 2, 1913.—EDITOR.

WHEN the "F-4" was finally located the day following her disappearance off Honolulu on March 25, it seemed at first hopeless to salvage her on account of the weight to be lifted and the difficulty of making lines fast at the great depth of three hundred feet.

The four divers who did the under-water work in connection with placing the pontoons from August 21st to 29th. The work was extremely arduous. From left to right the men are: Chief Gunner's Mate Evans, Chief Gunner's Mate Agraz, Gunner's Mate O'Brien and Gunner's Mate McMillan. These are not the divers who went down to three hundred feet, as they had returned to New York in June

The most direct method of lightening a submerged vessel is to close the accidental apertures and to pump out enough water to make the craft buoyant. In the case of the "F-4" this method of attack was entirely out of the question, because of the great depth of water.

All submarines are equipped with an internal air salvage line, having an outboard connection for the purpose of blowing the vessel free of water in case of just such an accident as that which occurred. This provision did not solve the salvage problem in this instance. In order to displace the water from the vessel it would have been necessary to deliver air below at one hundred and thirty-five pounds pressure — a problem in itself, as the pressure at the compressors would have had to be maintained at about one hundred and sixty pounds to overcome the friction in the great length of small hose leading to the vessel. Besides air salvage was finally disqualified because, even under the most favorable circumstances, it would have relieved the vessel of only part of the water, and because the ballast tanks could not have been thus emptied.

Any plan devised for recovering the submarine, therefore, had to be based on the proposition of lifting two hundred and sixty tons of dead weight from a depth of three hundred feet under salving conditions probably unprecedented.

RAISING THE "F-4" FROM A DEPTH OF THREE HUNDRED FEET

1. A dredge was anchored at one end, and the other end was moored to the submarine. It was necessary to have a fixed craft available for receiving the ends of the slings temporarily because it was never certain that the loop had been dragged to the desired position under the vessel until an inspection had been made by the divers

2. Four specially constructed windlasses were installed on two mud scows—two on each scow. The lifting cables were passed up through the mud pockets and secured to the windlasses. The craft was thus suspended2 in four slings. Wire cables were used, which chafed and eventually parted

3. After the wire cables broke, it was decided to use chains. As the submarine was lifted, a towing strain was kept on the dredge by a tug

Why Pontoons Could Not Be Employed in the Early Stages

The buoyancy of pontoons is ordinarily used to float a wreck when the vessel itself cannot be given positive buoyancy. In such cases the lift to be accomplished is usually small—sometimes only a few feet, which, by taking advantage of the tide, may be sufficient to take the ship off the bottom. If a number of lifts must be made in order to bring the vessel up, the pontoons are sunk almost to the deck level at low tide. The lifting cables are then hove taut. As the tide rises the pontoons are also pumped out. When the vessel is clear of the bottom the pontoons, with their suspended load, are towed inshore at high tide until the vessel again grounds. Sinking the pontoons and taking in the slack of the chains is repeated at the next low tide. If there is much rise and fall of tide, a considerable lift may be accomplished at each step. In this manner the wreck is gradually worked into shoal water or even landed in drydock.

In the case of the "F-4" the conditions for pontoon lifting were not favorable. The difference between high and low water is only about one and one-half feet off Honolulu. As the vessel lay in three hundred feet of water, a great many lifts would have had to be made. For these reasons it was necessary to bring the submarine up by mechanical means.

Four specially constructed windlasses were installed on two bottom-dumping mud scows—two on each scow. The lifting cables were passed up through the mud pockets and secured to the windlasses. Instead of securing the cables to the vessel, the loops of the cables were swept under the submarine and both ends taken to the windlasses, thus suspending the craft in four slings—two at about one-third the length from the bow, and two about the same distance from the stern.

How the Slings Were Placed Under the "F-4"

Placing the slings under the vessel was the most difficult feature of the salvage work. Four wire cables were used at first. A dredge from which the boom and bucket gear had been removed was used for the central unit of the salvage plant. This dredge was anchored at one end in the usual manner, as shown in the illustration. The other end was moored to the submarine by means of the lifting cables which were eventually transferred to the scows. It was necessary to have a fixed craft available for receiving the ends of the slings temporarily, because it was never certain that the loop had been dragged to the desired position under the vessel until an inspection had been made by the divers.

A New Record for Divers

The divers, while the vessel was in three hundred feet of water, set a new world's record for depth. The Bureau of Construction and Repair of the Navy Department had been experimenting for some time on deep-sea diving. It so happened that these experiments were brought to the point of practical application just before the accident to the "F-4." Four divers, in charge of the officer who had been conducting the experiments, were ordered from the New York Navy Yard to Honolulu as soon as it became apparent that the vessel could not be dragged into shallow water.

The diver does not wear a suit of special character when working in great depth as is the popular impression. The difference as compared to shallow water procedure lies entirely in the method of supplying air to the helmet and in the scientific restoration of the diver's body to the normal state by gradual decompression as he comes up from deep water. Air is supplied from flasks charged to a high pressure—suitably reduced before being delivered to the diver's helmet. The dangers in deep-sea diving are due principally to the absorption of nitrogen by the fluids of the body, on account of the high pressure to which the lung tissues are subjected and to the extreme exhaustion accompanying any kind of manual labor. For the latter reason the divers could not do heavy work at the three hundred-foot depth such as can easily be done by men working in shallow water.

After innumerable difficulties all four slings were swept under the vessel by means of tugs and the ends transferred

Dredge and scows used during the first phase of salvage work. Waiting for a diver to come up from 300 feet of water. In order to effect decompression gradually, the divers were sometimes two and a half hours in making the last one hundred feet back to the surface

from the dredge to the scow windlasses. This took from April 10 until April 21. On April 22 lifting the submarine by winding up the cables on the windlasses was started. As the cables were wound up, a towing strain was kept on the scows, thus bringing the submarine into shallower water.

One of the Lifting Cables Breaks

After lifting about twelve feet one of the cables parted in the loop, due to chafing on the bilge keels. This cable was one of the first to be placed, and had consequently suffered from chafing for almost two weeks, due to the continual motion of the dredge and of the scows in the swell. The broken sling was renewed and lifting was continued until the vessel was in two hundred and seventy-five feet of water. Bad weather now set in and accelerated the impairment of the cables, causing them to carry away one by one. It was now apparent that chain would have to be used for that portion of the slings in contact with the vessel.

The use of chain for the loop of the slings was considered when the salvage plan was first being developed, but was rejected, because chain does more damage to a vessel and is much harder to place than wire rope. These disadvantages had now to be accepted. A fifteen-fathom shot of two and five-eighth inch chain was accordingly shackled in to form a loop of each sling. The dredge was again moored as before by sweeping one and three-quarter inch wire lines under the bow and the stern of the submarine and bringing the ends to the corners of the dredge. The chain slings were finally placed in the same locations as had been occupied by the wire rope slings. Bringing these combination slings to position was considerably more difficult than placing the wire cables, because they were even heavier and more awkward to handle than the latter. After working twenty-one days, four slings were again in place under the vessel.

As the submarine was lifted a towing strain was kept on the dredge by a tug. This in turn brought a towing strain on the submarine. The arrangement proved more satisfactory than towing directly on the scows, because it permitted the scows

to ride in their normal state of equilibrium.

Once the slings had been made fast to the windlass drums, lifting was fairly rapid. After the windlass shafts had been filled with one layer of cable, it was necessary to cut off the wound-up portion and to shift to a new hold under the hook bolts. It was impossible to wind up a second layer, because of the enormous loads on the slings. One layer of cable corresponded to a lift of fifty-eight feet. The shafts could be filled in about two hours of actual lifting, but the work of cutting off and shifting to a new hold took considerably longer.

In spite of every effort one of the stern lifting slings could not be located quite as far aft as desired when it was put on, consequently it did not plumb the mud pocket through which it passed. This was immaterial in deep water, but as shallower water was reached, the sling began to bind on the framing of the pocket. When a depth of fifty feet was reached, it became necessary to shift the sling to a more vertical position.

A Storm Rises and the Submarine is Dropped for Safety

While this work was going on a heavy ground swell set in very suddenly. The swell increased rapidly and in a short time high surf waves were breaking near the submarine. The waves and the undertow from the reef caused the scows to charge back and forth with tremendous momentum. The after sling could not now be replaced in time to resume operations. It was apparent that considerable damage would be done to the submarine by the slings and that possibly the entire plant would be wrecked if an attempt were made to ride out the bad weather. The slings were accordingly cast off and the scows towed into the harbor.

The heavy seas continued for a number of days. As soon as the swell had subsided sufficiently, divers were sent down to examine the submarine. They reported that the forward slings had ruptured the shell and had caused the collapse of some of the framing one-third of the distance from the bow. This made it unsafe to continue operations by the windlass method, as there was danger of breaking off the forward end of the vessel while passing through the channel. This would have blocked the harbor to navigation.

As the submarine

End view of a lifting scow. Operations are suspended waiting for a diver to come up. Note the heavy purchase in the right foreground, leading to the hoisting engine for turning the windlass

now lay in somewhat less than fifty feet of water, it was possible to apply the pontoon method of lifting, but it was still impracticable to follow the orthodox procedure of lifting a few feet and towing to a new landing, because conditions were such that the vessel had to be raised in one operation to a draft of not more than twenty-five feet. This draft was fixed by the depth of water over the blocks of the drydock in which the vessel had to be landed.

To meet these requirements six specially designed pontoon cylinders were sunk alongside of the submarine, as shown in the illustration. The plan further called for the use of six chains rove under the vessel and passing through hawse pipes in the cylinders. The arrangement consisted in effect of a lifting of the submarine in a cradle made up of six chains.

The combined lifting capacity of the six pontoons was four hundred and twenty tons. A margin of one hundred and sixty tons was allowed for breaking the vessel away from the bottom and for any failure to utilize all of the buoyancy available in the pontoons.

Carrying the Submarine into Port on Pontoons

The chains were first of all worked under the submarine in predetermined positions, two forward, two amidships and two aft. The two chains of a pair were spaced sixteen feet apart so as to correspond to the distance between the hawse pipes. The pontoons were planted by means of a wrecking scow which was moored accurately over the submarine. The two cylinders of a pair were towed to the scene of operations and placed one on each side of the scow, directly over a pair of chains lying on the bottom as shown in the illustration.

The ends of the chains were now fished up through the hawse pipes and the cylinders submerged by opening the flood valves. They were kept under control while sinking by means of five-inch manila lines made fast to the ends and taken to the hoisting engines on the scow. The process consisted, therefore, in threading the pontoons onto the chains. After the pontoons had landed on the bottom the chains were adjusted so as to leave the necessary amount of slack to permit the pontoons to rise just clear of the vessel on becoming buoyant. A clamp was now fitted to each chain by the divers, just above the hawse pipe. The clamps consisted of two steel castings, moulded to the shape of the chain links and of such length that they spanned the hawse pipes. By means of four heavy bolts the two halves of the clamp were drawn together. These bolts kept the clamps from spreading and the chain from slipping through when subjected to the lifting strain.

After all six cylinders had been landed on the bottom alongside of the vessel and the clamps had been secured by the divers, the unwatering process was started. For this purpose torpedo air flasks, charged to a pressure of two thousand one hundred and fifty pounds were placed on a coal barge. The flasks were piped to an expansion chamber which in turn was connected to a manifold. Twelve three-quarter-inch air hose lines were led from the manifold valves to the blowout valves on top of the pontoons. A pressure of thirty-five pounds was used at the manifold for blowing out the water while the cylinders were resting on the bottom. The unwatering operation had to be watched very carefully so as to avoid the danger of springing the heads of the cylinders when the external water pressure was relieved on emerging.

The method proved successful in every detail. The work of placing the chains under the submarine was started on August 21. All of the chains were in position on August 25. It then took one day to place each pair of cylinders. This could be done only during daylight, as the divers could naturally not work in the dark. On August 29 everything was ready for blowing the water out of the pontoons. This operation took about two hours from the time the air was fully turned on. One end of the submarine came up slightly ahead of the other, as was to be expected. The vessel was towed into the harbor suspended from the six pontoons as shown in the illustration, and was docked the following day.

Eyes Were Made to See With

Do you know how to use yours? Read this article and then test them with the picture

1—Wire
2—Nail
3—Faucet
4—Chisel
5—Rule
6—File
7—Fly Swatter
8—Block of Wood
9—Bit
10—Incandescent Lamp
11—Keys
12—Pipe
13—Candle
14—Bolt and Nut
15—Fork
16—Cap
17—Revolver
18—Match-Box
19—Soap
20—Bottle

ONE of the fundamentals of life, to which comparatively little attention has been given, is the ability to see straight. Very few of us see what is placed before us or what goes on under our very noses. Fortunately this faculty of observing correctly may be improved by practice, but first we must be made to realize that we are deficient in it. To prove this to classes of young engineers, Mr. W. H. Blood, Jr., performs a very simple experiment.

He has found it interesting to test his classes to see how far they have cultivated their powers of observation. On a board are mounted twenty objects, ten of them being ordinary household articles and ten of them simple mechanical or electrical objects. This is reproduced in the accompanying photograph. The numbers are not on the board itself but are used in the illustration for the sake of identification. The board is displayed before the class and the observers are allowed to look at it for a predetermined time; then the exhibit is covered and they are asked to write down the articles which they have seen. While this test in psychology does not prove much of anything, an analysis of the answers obtained certainly does give us food for thought.

A recent experiment of this kind, tried on a large group of technical students, gave some startling results. Here was a group of educated young men who for half a minute gazed intently at these twenty articles. Several saw only three or four of the articles; the average for an entire class was but eight. What was the matter with these boys? Half awake, you say? Oh no, they were all wide awake, none more so. The test simply shows that these students have not been taught to observe. How can they make clear deductions if they are unable to tell what they have seen? Some of the men said the color of the burlap which covered the board was white, while others said it was black, yellow; only few said it was brown or buff. A curious fact brought out by this test was that nine out of ten put down on their list articles which were not on the board at all; they drew on their imaginations, but their guesses were not right. Of this entire class the best observer had but fourteen out of the twenty correct,—equivalent to 70 per cent; the average was 40 per cent, and the poorest was 15 per cent correct. A pretty poor showing for a group of technical men.

Although Bushnell and Fulton had both demonstrated the practicability of navigating a vessel under water, Germans took but little interest in the subject until 1850. In that year Wilhelm Bauer, whose portrait appears to the right, built the U-boat illustrated. Bauer served as a Bavarian artillery officer in the Danish War and had ample opportunity to note the havoc wrought by Danish warships on Schleswig-Holstein troops. He thought it would be easy to build a submarine boat which would destroy the Danish warships. The Prussian government was not very encouraging, and so he had to build his vessel with the aid of private citizens

In the oval, a squadron of German submarines. Two types of submarines have been developed, known in this country, respectively as the Holland and the Lake types. Americans are prone to regard Holland as the pioneer submarine inventor

The photograph to the left shows the great gaping hole blasted in the side of an unarmored ship by a German torpedo. The latest type of German submarine carries from ten to twelve torpedoes. It is equipped with six torpedo tubes (four ahead and two astern). In the nose or warhead of a torpedo from five hundred to seven hundred pounds of guncotton are carried—a high explosive of terrific possibilities as the picture convincingly testifies

Take Kindly to Its First Submarine

The two photographs to the right show respectively the internal operating mechanism and the exterior of Bauer's ill-fated submarine. The boat was propelled by means of pedals and a train of gear wheels and cog wheels. The "Brandtaucher," (Fire Diver) as Bauer's boat was called, made just one trip in Kiel harbor. That was in 1851. The boat foundered, but fortunately the crew was rescued. The vessel was not strong enough to stand the pressure of water when submerged. In 1887, thirty-six years later, the government undertook some dredging in Kiel harbor for the purpose of building a torpedo basin. Bauer's submarine was then discovered, raised and transferred to the courtyard of the Berlin Naval Museum, where it may now be seen. The submarine is a product of many lands and many minds. Even in ancient times efforts were made to navigate vessels under water—apparently with little success. Napoleon gave the subject some thought. It was with him that Robert Fulton dealt. The submarine, as we see it, combines the ideas of Bushnell, Fulton, Nordenfeldt, Holland and Lake

To the left, a German submarine of an early type shown in section. Below, a German submarine of a late type. These late submarines have a radius of action of about 2,000 miles; that is, after having filled their oil tanks they can travel for that distance before it becomes necessary to replenish their fuel supply

Taking Photographs From a Skyrocket

AMONG the aids to the conduct of the war that have been proposed in Germany is the photography of the enemy's positions by the flight of rockets carrying cameras. The invention is less expensive and can be sent up closer to the enemy without provoking attack than a captive balloon, dirigible or aeroplane. Besides, it is not so dependent upon the wind as a kite.

When the inventor, Alfred Maul, began his experiments fifteen years ago, he found, as he tells us in an article appearing in *Umschau*, that the ordinary rocket can hardly carry a considerable weight, and so he was obliged to devise one of greater strength.

His first invention was a shell closed above and open below containing a firmly compressed powder composition in which was a deep opening. Ignition developed a considerable volume of gas, which gas pressed down upon the atmospheric air, thus causing the rocket to rise. In a shot the initial velocity is the highest, whereas in the rocket the initial velocity is low but increases until the charge is burnt out. This occurs in about one and one-half to two and one-half seconds, but the rocket continues to rise, through the force generated, from six to nine seconds.

In his first camera experiments Mr. Maul used two small rockets combined. Here the rotary camera, which could take a picture about one and one-half inches square and had an oblique downward inclination, was in a hood above the rockets. At the sides of the rockets were two chambers containing parachutes of unequal size. The guide-staff had two vanes at its lower end, like an arrow, to prevent rotation and change of direction of the lens. At the highest point of the flight a time-fuse raised the shutter and threw out the smaller parachute. Just before landing, the larger parachute was opened. The double rocket could carry a load of over half a pound and rose about one thousand feet.

Failures accompanied successes in the tests. Rockets exploded, parachutes dropped at the wrong moment and much costly apparatus was destroyed, before the inventor saw the cause of his misfortunes, which was that the time taken for ascent depended on the density and moisture of the air. The exposure and release of the parachutes were, therefore, arranged independently of the period of ascent, by making the upper part of the hood resilient and equipping it with an electric contact device. When the rocket paused for a moment at its highest point of ascent, the contact opened the shutter and directly afterward threw out the first parachute. This proving successful, the photographic apparatus was enlarged to a diameter of eight and one-half inches; the plates were made four and three-quarters by four and three-quarters inches, the focal distance was also four and three-quarters inches. The length of the equipment was now over thirteen feet and the weight thirteen pounds. As the apparatus was still inclined to rotate on its axis corrective experiments were made, but the rocket proved unable to carry the weight of a special governing apparatus. Finally, a gyroscopic device was arranged which works automatically when the rocket

View of a German town taken with a rocket from a height of 1,550 feet

How the Skyrocket Camera Works

Ignited by an electric device, the rocket darts upward sixteen hundred feet. An electric contact opens the camera shutter and releases the parachute which returns the camera in safety

The apparatus needed to fire the skyrocket camera. Above, a view just as the rocket is about to be put in place. At the left, ready to be shot. Below, packed and ready to m[illegible] away

rises and does not permit rotation.

The present apparatus can rise to a height of sixteen hundred feet. Its length is twenty feet, its weight about fifty-five pounds, and the pictures are seven and one-quarter inches square. Its parts are shown on the preceding page. The guide-staff about fifteen feet long is made in two united but easily separable parts, the upper being bolted to the rocket, the lower carrying the vanes, as shown.

When ready for use the rocket is mounted on a collapsible, heavy frame carrying the sighting device and weighing about eight hundred and eighty pounds. The rocket is ignited by a distant electric device. The weight immediately runs down and the charge is fired, driving the rocket up one thousand, six hundred feet in eight seconds. When near the highest point of ascent the contact in the top of the hood opens the instantaneous shutter and releases the parachute. As the parachute opens, the rocket divides into two parts, connected by a thirty-two-foot belt. The hood and camera hang just under the parachute, while the container and staff swing about thirty-two feet below. The parachute, relieved of extra weight, lands the camera without jar in sixty seconds.

Our Bad Tempers

What makes you angry? Why do you fly in a rage when the soup is salty? Blame it on your grandfather

By G. Davenport

THAT bad temper is due more to an inside state than to outside conditions is demonstrated by the fact that the same mild stimulus causes so much more violent behavior in some individuals than in others. In other words it takes little or nothing to make some persons lose their temper. They lose it easily, just as children do, because they lack the braking power or ability to shut off this violent reaction. Liability to outbursts of temper is confined to no stratum of intellect or social position. The choleric may be rich or poor, stupid or intelligent. Bad temper is an emotional rather than a mental disturbance. Concerning the causes of this disturbance we know little. We know that over-eating and drinking, bad digestion, intestinal stagnation and exciting situations are contributory factors. But what may cause an irritable state in one may not ruffle another. To account for this difference, we are brought around again to the matter of individual constitution, *i. e.*, to the fact of heredity. In many cases that have come under institutional observation there is not infrequently a regular occurrence of tantrums at monthly or more frequent intervals. It would seem as though there were an accumulation of some substance in the body, in consequence of which the nervous system becomes so irritable that an explosion results from the most trivial cause.

Bad temper is especially frequent in families that contain epileptic, hysterical or insane relatives. Epilepsy and insanity, however, are not necessarily indicated by outbursts of temper nor does a choleric temper invariably accompany these disorders; for there are mild tempered epileptics as well as maniacs. The paralysis of the braking mechanism upon which tantrums depend, seems, however, to occur most readily in those individuals whose nervous and other body functions are defective in other ways.

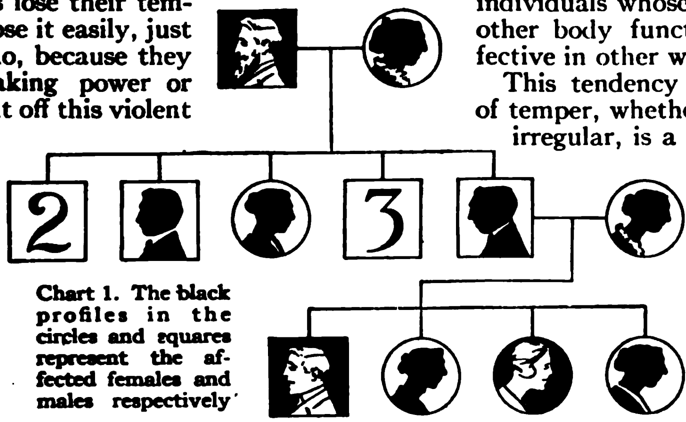


Chart 1. The black profiles in the circles and squares represent the affected females and males respectively

This tendency to outbursts of temper, whether periodic or irregular, is a return to an infantile emotional condition. Children are more given to displays of temper, on the whole, than are adults, just as monkeys are much more capricious, on the whole, than men. Thus ill-tempered families have either reverted, in this respect, to a more primitive condition or else they are retarded in the evolution of this trait.

Whatever may be the racial history of the trait, its present hereditary behavior is not obscure. We know that it is handed down in certain families from generation to generation without a break. That is to say, some members of each generation will possess this unsocial trait and others lack it. Those that show it, transmit it in turn; but those without it cannot do so. Traits that do not skip a generation are known in the language of modern heredity as dominant traits. Just how complete may be the dominance will depend on the hereditary history of both parents. There is an hereditary combination possible that will produce 100 per cent choleric; that is when both parents are choleric and belong to pure choleric strains.

The accompanying charts illustrate

the law of the inheritance of this trait. The circles represent females and the squares males. The black profiles in the circles and squares represent the affected females and males respectively. Chart 1 starts with a female—a grandmother who had three bad-tempered children, two sons and one daughter. One son married a bad-tempered woman. Two of his daughters are notoriously ill-natured. One of them is under custodial care.

That the shrewish do not always hark back to female progenitors is well illustrated in Chart 2, which includes five generations. In this chart the first fiery-tempered progenitor of whom we can get record is a great-great-grandfather. He has transmitted tantrums through son, grandson, great-grandson to his great-great-grand daughter, whose behavior is such that she should end her days in the state institution in which she is now an inmate.

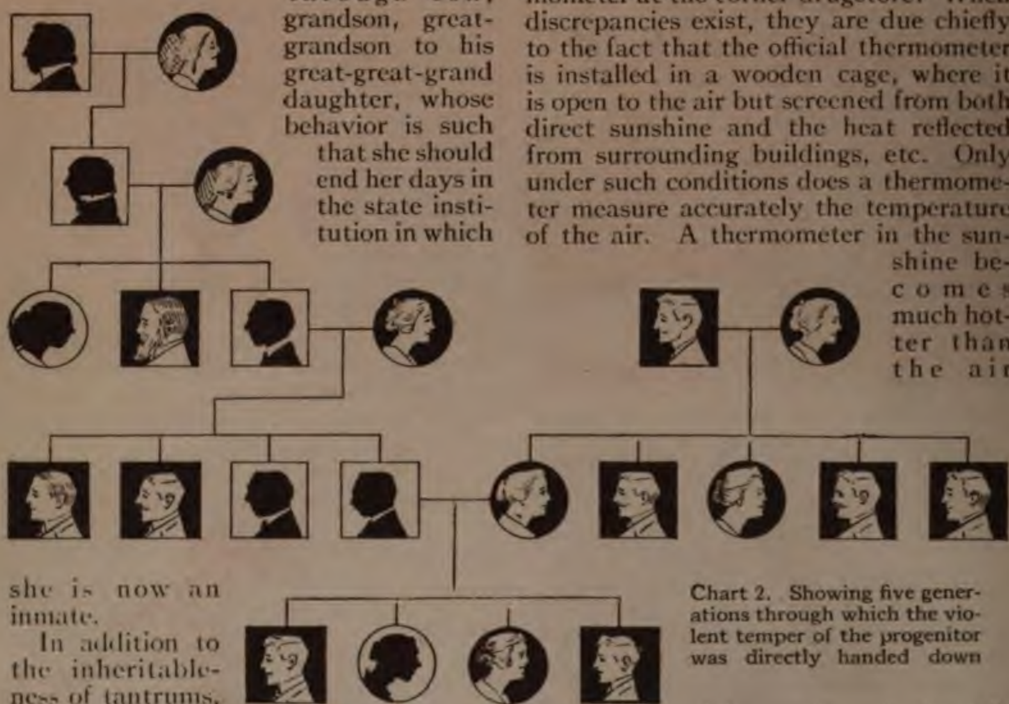


Chart 2. Showing five generations through which the violent temper of the progenitor was directly handed down

In addition to the inheritableness of tantrums, these charts demonstrate that bad temper is one of the contributory causes that fill our houses of correction. These institutional cases come almost wholly from the unintelligent. Intelligent and conscientious persons will wish to do everything in their power to control temper. Abstemiousness in food and drink, sufficient sleep and attention to health in general, *may avail* something. The imminent outbursts may be counteracted by physical exercise or a prolonged, soothing bath. The internal irritants seem to be destroyed or gotten rid of by these means. Much may be accomplished by establishing the habit, even at great effort, of ignoring irritating situations. When the intellect is too weak to cope with the situation or the temper is so furious as to be beyond treatment, then custodial care is advisable both from the standpoint of the individual and of society.

The Difference Between a Store Thermometer and an Official Thermometer

WHY does a Weather Bureau thermometer show lower temperatures in hot weather than the thermometer at the corner drugstore? When discrepancies exist, they are due chiefly to the fact that the official thermometer is installed in a wooden cage, where it is open to the air but screened from both direct sunshine and the heat reflected from surrounding buildings, etc. Only under such conditions does a thermometer measure accurately the temperature of the air. A thermometer in the sunshine becomes much hotter than the air around it, and its reading simply tells us how hot the instrument is, not how hot the air is. In large cities the Weather Bureau thermometer is often installed on the roof of a high building, where the temperatures differ somewhat from those prevailing at the street level. The object sought in this arrangement is to obtain a record of the natural temperature of the locality in general, rather than the artificial temperatures of the city.

Raising Parasites to Fight Pests

ructure Erected in Connection with the
rasite Laboratory Where the Gipsy Moth
d Other Pests Are Trapped and Studied

MANY methods of exterminating injurious insects have been tried, some proving useless and others, while effective, being only temporarily so. Perhaps the most scientific work yet attempted is the cultivation of natural enemies, which in time would annihilate the insects upon which they live. The gipsy moth and brown-tail moth are particularly injurious. Both are natives of Europe and were early introduced into Massachusetts, where they have committed yearly ravages on fruit and shade trees. Can no enemy which will devour them be found?

In 1905, work was begun under Federal supervision to answer that question. Dr. L. O. Howard, chief of the Bureau of Entomology, and Dr. W. F. Fiske, in charge of the Gipsy Moth Parasite Laboratory, Melrose Highlands, Mass., have expended time and energy in their unceasing efforts to rid the country of these harmful insects.

While at least a dozen parasites have been reared from the gipsy moth, and although a variety of American parasites are natural enemies, the aggregate effectiveness of all the species together is wholly insignificant. It is possible, however, that the caterpillars may be attacked by parasites, the larvæ of which may be rendered unable to complete their transformations under the conditions in which they find themselves.

Since insects like the gipsy moth and the brown-tail moth are subjected to the

An Apparatus Similar to an Ordinary Show-Case, the Glass Sides Being Supplanted by Cloth in Which Sleeves Are Set Through Which the Nests May Be Handled Without Any Danger

attack of different species of parasites at different stages in their development, it has been necessary, in order to secure all of these, to import the host insects in as many different stages as possible and practicable. Importations of large caterpillars, ready or nearly ready to pupate (go into a sleeping state) were first made in 1905. It was demonstrated during that year that they could be brought to America with a fair degree of success and that at least a proportion of the parasites with which they were infested could be reared.

One of the greatest difficulties, experienced from the outset, has been the acclimatization of the parasites. The ones thus far cultivated have a tendency toward rapid dispersion over a wide area, thus hindering colonization. Even though a large number of individuals are released, their spread is so rapid that the possibility of meeting and mating is soon lost.

Perhaps the most serious handicap to the progress of the work is the preservation of the health of the assistants in the laboratory. The irritating and poisonous hairs of the brown-tail larvæ, of which the nests are full, penetrate the skin of the assistants, entering their eyes and throats and almost filling the atmosphere of the laboratory. It was soon found necessary to keep the rooms thoroughly closed. Double windows were used, and the doors, too, were doubled, in order that a possible secondary parasite, if accidentally liberated, should have no chance of escape. This made the rooms very warm and increased the irritating effect of the larval hairs. Spectacles, gloves, masks, and even headpieces were invented, but they only increased the heat and were not entirely effective in *keeping out* the troublesome hairs.

Spectacles, Gloves and Masks Are Worn by the Laboratory Workers as a Safeguard Against the Irritating Effect of the Gipsy Moth's Hairs

Dr. Fiske finally devised an apparatus similar to an ordinary show case, the glass in one side being replaced by cloth with armholes, through which the gloved hands of the worker could be thrust and the brown-tail nests handled in full sight through the top glass. Much of the rearing of brown-tail larvæ must be carried on under conditions in which such cases cannot be used, and so the old difficulty still exists.

It is hoped that the parasites already introduced will in time prove sufficient for the purpose intended. Only events themselves can be depended upon to answer this question. Unfortunately the moths continue to disperse and multiply in the meantime.

Why Whiskers Continue to Be in Style for Cats

ALTHOUGH hirsute adornments of all kinds, whiskers included, were once the real and indispensable thing, modern sanitary practice has made such inroads on unharvested beards and long hair that only a few scattered humans such as musicians and soap-box orators still retain their hairy luxuriance. Notwithstanding this, however, the house cat has grown and nurtured its crop of whiskers or feelers for the last million years or so without bothering about hygiene.

The fact is that the cat's whiskers are absolutely necessary to it. The whiskers are as long as the cat's head is wide, and the head is as wide as the body, so wherever the whiskers go there may the cat go also.

The tiny, delicate hairs grow from a gland and are nerved to the utmost sensibility. No matter how light the touch of the hair against an obstacle it is instantly felt by the cat.

oying with High Tension Currents

At left, Prof. Thordarson and his helper and operating expert, Mr. Lindstrom

Below, using an umbrella to experiment with a three to six-inch spark from the safety-screen

LECTRICAL science has brought forth so many startling discoveries in the last decade or two that even average person is rather proof against g astonished at anything. Almost edible accomplishments of an inven- years of unremitting labors are n dismissed with the faint praise electricity is only in its infancy. almost all other things, however, e are exhibitions of electric force tickle the public fancy without veying any idea of commercial worth. ood example of this is seen in the trical displays with high-frequency ents, the beholders little realizing they are interesting applications of same power employed in wireless raph transmission.

remarkable electrical construction ch has excited great interest in both curious spectator and the far-seeing neer is the 1,000 kilowatt, 1,000,000- , 60-cycle transformer, constructed the well-known electrical instrument er, Mr. C. H. Thordarson of cago. Requiring two years' time in truction, costing $36,000 and entail- no end of thought and ingenuity, it primarily made to demonstrate certain theories on transformer construction and to investigate the behavior of electric conductors when charged with extremely high voltages.

Electric currents, when traveling at very high frequency, pass almost entirely upon the surface of the conductor. The resistance of such a circuit is therefore so high that unless a high voltage is operating no current at all will flow. Such conditions are met in stage apparatus. Ordinarily the operator can handle the conductors with impunity, the current merely passing through his outer skin or perhaps entirely in his clothing. The alternations may readily be a million per second or half that number of "cycles" per second. In the case of ordinary electric light and power circuits the most common frequency is 60 cycles per second, some, however, being as low as 25. In such cases the current flows quite like the direct sort, uniformly through the section of the conductor, whether it be wire or person, and a voltage as low as 1,000 is likely to be fatal. It is realized, therefore, that in the new Thordarson apparatus there is found for the first time the combination of the high voltage with ordinary

commercial frequencies. Some of the large manufacturing companies have, in recent years, constructed testing transformers for this same sort of circuit, but of only about half the voltage. Only those who have worked with very high voltages can realize the difficulties attending the construction and maintenance of such a special piece of apparatus.

While no one is as yet fully aware of the possibilities of this high power transformer, its electro-static effects are the most marvelous ever exhibited. Strangely enough, the spectators can actually toy with the powerful charges. Crowds of people at a time could walk through an "electrified" area 50 ft. square and 30 ft. in height, yet with no opportunity for dangerous contact. The general arrangements at the Panama-Pacific Exhibition for a demonstration were made in a building with convas end containing the transformer and its controlling accessories, while under the large wire screen suspended by ropes from four electric light poles the visitors could pass and experience the peculiar and vivid sensations of high-voltage charges. Those wearing hat-pins, hair-pins, metal buttons, or carrying metal-handled canes or umbrellas, or even metal-bound purses with their coins, etc., were mysteriously "tickled" and provoked to amusing exclamations of surprise or fright. By holding the hat aloft one could draw sparks from the hat-band; by holding grounded metal conductors at arm's length 12-in. sparks could easily be drawn from the insulated rope safety-screen suspended 10 ft. below the charged screen, each discharge being accompanied by a diminutive thunder-clap. By merely standing on a box or some other insulating material and raising the hand, sparks three to six inches in length could readily be drawn and then passed along to persons standing on the ground. Vacuum tubes and incandescent lamp bulbs brought beneath the screen were continuously illuminated with the blue glow peculiar to such influence.

On dark nights the entire aerial system was a mass of soft glowing "corona," the needle-points of discharge, or places of great concentration of electric spray, sizzling with the wonderful wizardry of electrostatics. On some occasions a corona a foot in diameter was observed surrounding some of the metal conductors. When a grounded water-jet spouted upward against a metal disk suspended from the charged screen the resulting luminous display of electric pyrotechnics was awe-inspiring; the length of the luminous discharges measured over 20 ft., while miniature thunderclaps reverberated to surprising distances. Some of these highly entertaining and amusing "stunts" are shown in several of the reproductions accompanying this article.

This is not a mop, which Prof. Thordarson is holding. Sparks are leaping to the top of a pole in his hand. From the safety-screen high-voltage charges and thunder-claps are coming

At left, view of aerial screen system and secondary apparatus for collecting charges. At right, public demonstrating screen suspended thirty feet above ground by four poles

At left, spectators experimenting with apparatus. One boy is waving a vacuum tube. At right, Prof. Thordarson examining his one million-volt, sixty-cycle transformer

Engineers are of course interested in the details of construction of such a transformer, and some of the facts have been generously given by Mr. Thordarson himself and by his assistant and operating expert, Mr. A. S. Lindstrom. The laminated iron magnetic circuit is arranged on the "core" type, with both primary and secondary windings grouped upon one leg only. Horizontal members are 120 ins. in length, the vertical ones 40 ins., their section being 16 ins. by 16 ins. Primary winding consists of 122 coils of 44 turns each of copper ribbon, .020 in. by .281 in. in section, being the equivalent of a No. 12 round wire. These coils are placed ¼ in. apart, pairs being connected in series, then the 61 groups connected in parallel for receiving the 2,200-volt supply. When assembled, the primary portion formed a cylinder 67 ins. long, 23 ins. inside diameter, 28 ins. outside diameter. As a protection from electrostatic surges the junctions between the pairs were connected to a heavy copper bar that was thoroughly "grounded" to frame and earth. Over the primary coils was a specially prepared paper cylinder 92 ins. long, inside diameter 29½ ins., outside 41½ ins., therefore 6 ins. thick.

For the high voltage secondary winding 190 separate coils were used, each adapted for 5,300 volts, being all connected in series. Each coil consists of 212 turns of aluminum foil, .008 in. by .135 in., with three thicknesses of .006 in. paper between turns, and when finally assembled forming a tube 71 ins. long, 43 ins. inside diameter, and 51 ins. outside diameter. The construction of this secondary was of course the crucial part of the whole experiment, and the ingenuity that was brought out to cope with the different problems is of the greatest credit to the designer and builder. In general, the principle of construction adopted, that of breaking

up the winding into numerous separately insulated coils, was first utilized by Ritchie, the famous instrument maker, in Boston, as early as 1846, and then copied in the well-known Ruhmkorff induction coils, and now a common affair with all builders of transformers, but the application of the principle in this million-volt winding demanded a refinement of details not heretofore called for. Of course the whole structure required that its windings be protected from absorption of moisture.

A Railroad Which Fights Its Own Fires

THE Transcontinental Railway of Canada is going to fight its own fires in the future. This is saying a great deal, since every other railroad in this country and Canada depends on available city firemen when railroad property catches fire, and when city firemen are not handy allows its property to burn up, helpless to save it because of lack of equipment.

When fires had destroyed valuable timber lines along its right of way and threatened to wipe out whole counties if something was not done to find an efficient means to combat it, the Transcontinental Railway placed an order with the Canadian Government Railways' Shop at Moncton, New Brunswick, for a fire-fighting apparatus. The car illustrated herewith is the result, and it is now in operation.

The apparatus consists of a large water tank of more than ten thousand gallons capacity mounted on a flat car in order that it may be transferred to any point on the system where fire may be threatening. A steam-driven duplex fire pump which has a capacity of three hundred gallons a minute is mounted on the tank. The steam supply for operating the pump is taken from the car heater of the locomotive to which the car may be attached, and by setting the car heater regulator of the locomotive at a pressure of one hundred and twenty pounds per square inch, a water pressure of about one hundred pounds is obtained at the nozzle tip.

Before the apparatus was sent to the Transcontinental Railway the device was tested and found to be capable of throwing two one-inch streams of water a distance of about two hundred feet to either side of the track. This will enable the fire-fighting railroad company to extinguish all fires which occur within its right of way.

The fire-fighting apparatus is kept under steam so that it can be quickly transferred to any point on the railroad's system where fire may be threatening property worth millions

How to Make Knots, Ties, Hitches and Bend's

The Timber Hitch, a safe and simple knot usually employed in holding poles and booms. The turns in the loose end must be carefully made

The Double Bowline is used when the end cannot be used, and when a loop is desired in the bight

The Single Bowline is one of the most important of all the hitches. It is very safe and will not slip or jam

The Timber and Half Hitch. Much the same as the Timber Hitch with the addition of a half hitch to avoid any danger of the rope's rolling

The Square or Reef Knot is one of the safest ties, but care should be taken to avoid a "granny"

The Blackwell Hitch, while safe for light loads, is likely to part under heavy strains

A "safety-first" tie, the Cat's Paw. This hitch will sustain heavy loads, and is most us d for that reason

When the rope is too long, it may be shortened by the use of this knot, the Sheepshank

The first operation in preventing the dead end of a rope from ravelling

The Clove Hitch is a very safe knot, and may be handled very quickly

The Stopper Hitch is used to hold the strain in the fall line of blocks

The second operation in preventing the dead end of a rope from ravelling

What Make of Car Is It?

By Prescott Lecky

New York's police receiving instruction in automobile identification. Fifty-four different machines are thoroughly learned so that only a glance is needed to tell the make of car

Every visible part of an automobile is considered separately. To simplify matters, the car is likened to a human being, identification being from three angles—face, profile and rear as the charts on the picture below show

HAS your car a Roman nose, or is it pug? Do its ears stand out or lop over? Its eyes—are they far apart or close together, deep-set, large, high or low?

This is by no means nonsense. It is the method of automobile identification now being taught the two hundred and fifty policemen who guard the outlets of New York city, such as ferries, bridges *and main roads.* The characteristics of the different makes of cars have been compared and the individual features, or "factors of identification" carefully

sorted. Of two cars similar in other respects, for instance, one may have three oblique ventilators while the ventilators of the others are vertical. If no other car possessed a similar mark, it would constitute a factor. Such factors may be found on any part of the car: mudguards, headlights, radiators, hoods, gas tanks, tire carriers, springs and so on.

To simplify the system, the car is compared with a human being, and the patrolman is taught to identify it from three angles; face, profile and rear. Furthermore, since he recognizes each make by the factors, the trained patrolman makes a better identification for police purposes than would be possible for even the most experienced chauffeur, since he can swear to his evidence. He can cite the factors he observed as proof, whereas the chauffeur, though equally certain of his case, has nothing to support his decision as a rule except general facts. True enough in itself, nevertheless the cross-examining lawyer can make such evidence almost worthless.

In watching for a certain car in the traffic the patrolmen are taught to use the factors for rapid elimination, after Sherlock Holmes' famous precept of "observation, knowledge and deduction." If the car in question has a crown mudguard, for instance, one glimpse of a flat or oval mudguard is sufficient information. He drops the machine at once. Observing the remaining cars, or those with crown mudguards, he finds contradictory factors in all except the one he seeks.

All of the outlet posts of the city are connected with a single alarm system, and the descriptions of stolen cars, cars containing escaping criminals, or those wanted for any other reason, are communicated as soon as the crime is reported. The importance of training these outlet men to know the various makes is obvious. Eventually every man on the force will receive some instruction along these lines, and a short course has already been incorporated into the schedule of training for recruits.

Note the face, eyes and ears of these cars and how they differ from one another

An escaping machine can be identified by the position of the tail-lights

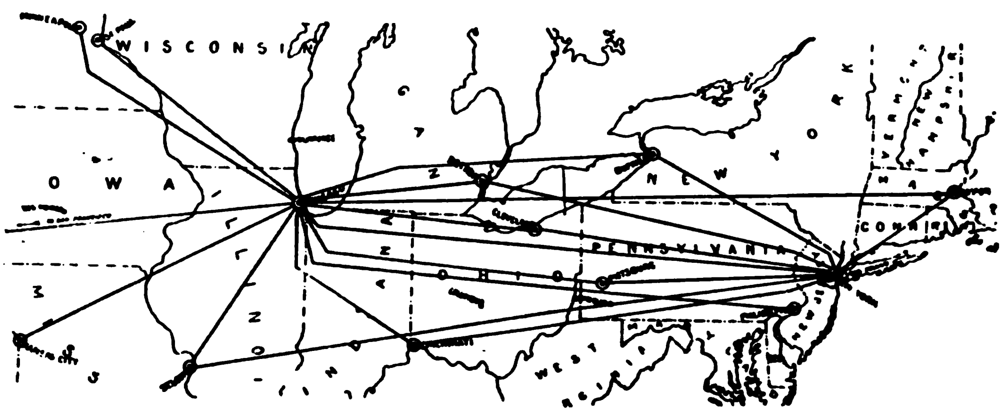
The "nose" of an automobile is a good index to its lineage

Typewriting Eight Telegrams Over a Single Wire

WHEN the possibilities of sending messages over a wire by electricity were first realized, soon after Morse demonstrated the first telegraph, the limitations in the message-carrying ability of a plain circuit were encountered. The ordinary good operator could send only about one complete message per minute, and to do this he required the full use of a wire connecting him with the receiver. Each line was thus limited to about four hundred messages per business day, and it became clear that extremely high rates would have to be charged for messages over expensive long distance wires. The greatest cost of the telegraph system was due to the erection and maintenance of the lines, and therefore the best way to make lower charges possible appeared to be to increase the number of messages which could be handled on each wire.

The first step toward solving the problem of message limitation came with the duplex telegraph, which made it possible for four Morse operators to use a single wire at the same time. In this system two streams of messages pass over the wire simultaneously, in opposite directions, so that the capacity is doubled. The next step was the quadruplex, in which four messages are sent simultaneously, two in each direction, over the same wire. In this system one line carries about sixteen hundred messages per day, and large saving, as compared to plain or simplex single-message telegraphing, results. The duplex and quadruplex are very greatly used today, and the latter is not easy to keep in full operation during rainy weather. An octuplex system was devised, but has not been found practical.

Since the hand-telegraph systems are limited in message capacity by the speed of the Morse operator, automatic receivers and transmitters were devised to speed up the impulses passing over the line. In the Wheatstone system, which is perhaps the most successful of the plain automatic telegraphs, it is possible to send three hundred or four hundred words per minute over one wire, thus increasing the normal capacity some ten or twelve times. In this system the messages are first punched into special tapes by perforating operators. The tapes which are simultaneously punched out by ten perforators, will usually keep one wire in full operation. At the receiving station the messages are printed in dots and dashes on a second tape; this is divided into suitable lengths and distributed amongst a number of transcribing operators who



This remarkable telegraph system has been in operation over the lines shown for many months, and has resulted in the saving of much time and money to the company, and eventually to the senders

translate the Morse code and write out the messages for delivery. The system is entirely practical, and is used in connection with the ocean cables. In the United States it is not favored for inter-city telegraphing because of the loss of

The receiving instrument. A telegraph blank is inserted in the instrument, and as the perforated tape passes through after receiving its impulses over the wire, the message appears in typewritten form, ready to be delivered

time which results from the series of processes through which messages must pass.

Automatic telegraphy suggested printing telegraphy, in which the message received appears in typewritten form. The first of these instruments, like the stock-ticker, printed their messages on paper tapes. Soon it became possible to operate page-printers over considerable distances by wire. In these a typewriter keyboard transmitter, either directly or through a punched tape, operates over the line a typewriter receiver. The message is thus printed ready for delivery almost as soon as the transmitting operator punches it out on the sounding keyboard. Such printing systems usually operate up to fair typewriting speeds of fifty words per minute or so, and can be duplexed. By their use much time and expense in message handling are saved, and the good features of present-day rapid wire line service are largely due to these installations.

The newest and most perfect page-printing telegraph is that which the Western Electric engineers have recently completed. In this system a single wire is used not only to carry eight messages simultaneously, four in each direction but to print them on blanks at the receivers, ready for delivery. Thus the speed of direct printing operation (fifty words per minute) is combined with a distribution of one telegraph line among eight pairs of sending and receiving operators. The increases of speed and economy produced by such an arrangement are almost self-evident.

A sending operator at the keyboard perforator. This instrument is much like a typewriter, but instead of printing the letters a group of punches are controlled by the keys and punch a tape with various combinations of holes

The apparatus used in this new quadruple-duplex system is built up in a group of transmitting, receiving and accessory units. One of the illustrations shows a sending operator at the keyboard perforator. This instrument is much like a typewriter, but instead of printing the letters a group of punches are controlled by the keys and perforated [illegible]

tape with various combinations of holes. In the illustration the fresh tape may be seen unrolling from the reel back of the rack carrying the message about to be sent. After perforation at the left end of the keyboard machine, the tape passes under the pivoted arm of an automatic stop and then into a transmitter unit (at the extreme left of the photograph). The operator ordinarily punches tape at

These eight operators work at one end of a single trunk line. Four are sending and four receiving, and they are kept busy every minute. The same number work on the other end of the wire, and it is possible to send more than six thousand messages over one wire in a single working day

about the speed of transmission, so that a little slack tape hangs under the control arm of the stopping device. Should he fall behind, however, as soon as the transmitter uses up the loose tape and so begins to stretch it tightly between the two machines, the control arm is lifted. This operation automatically stops both the local transmitter and the receiver at the distant end until more letters are perforated. Then the tape slackens, the control arm drops and transmission begins again. Thus the printed message appears complete and without blanks, even though the transmitting operator is forced to stop in the midst of perforating.

The printing receiver is shown in another photograph. Inside the case a message is being typewritten as the perforated tape corresponding to it passes, letter by letter, through the transmitter. Each group of five impulses (one for each row of punched holes in the sending tape) prints a single letter, makes a space between words or starts a new line on the printed page by returning the paper-carriage to the right and turning up the paper. At the end of each message a short time is allowed for the receiving operator to take out the printed telegram and insert a fresh blank; while the new message is being typed he checks over that which has just been received and, if it seems correct, turns it over to the delivery department.

The printing, ready for delivery, of keyboard-perforated messages, could be accomplished by any of the older successful page-printing telegraph systems. In fact, the same line could be duplexed and messages sent at about fifty words per minute in both directions, so keeping four operators at work on a single wire. But the new printing telegraph is capable of handling the telegraphic output of eight transmitters and thus keeping sixteen operators busy over one line. This simultaneous transmission of messages is made possible by the use of a pair of special distributors, one at each end of the line, which successively switch in and out each of four sets of instruments. The line is duplexed and therefore permits messages to travel in both directions at the same time; for each

quarter revolution the distributors connect on the line four operators using one duplex "channel" set, which consists of a sender and receiver at each end.

The operation of the two distributors is perhaps the most important new thing in this system, since it is through them that the line can be used successively by each of the four groups of four operators. The simple fact that in printing telegraphs over three-quarters of the total time of operation is used for preparing to send, and in printing the letters, while less than one-quarter will suffice for the actual transmission of the five electrical impulses, has made possible this distribution and simultaneous operation. The distributors are merely special rotary switches which revolve, one at each end of the wire, at exactly the same effective speed. For each quarter revolution the duplex line is connected to one set of instruments and the impulses forming one letter are transmitted in both directions. If the distributor rotates at three hundred revolutions per minute, three hundred letters or fifty words per minute will be sent in each direction through each of the four channels, making a total of four hundred words per minute. Each revolution of the distributor is accomplished in one-fifth of a second, and during each quarter of this period, or one-twentieth of a second, each set of instruments is connected to the line. In the three-twentieths of a second the receiving printer operates and the transmitter prepares to send the set of five impulses corresponding to the next letter in its message.

The other photograph shows the eight operators, four sending and four receiving, who work at one end of a trunk line using this new quadruple-duplex printer.

The problem of bridging a mountain stream, circling the edge of a precipice and "tacking" up a steep grade forced the engineers responsible for the electric railway up Mt. Lowe to make this queer "circular bridge"

A Circular Bridge on Stilts

THE circular bridge shown in the illustration is unusual both in its design and in its location. The trestle work forming almost a complete circle, practically all of which is "on stilts," is a part of a mountain inclined road. At the point where the roads almost meet, one track is about six feet higher than the other. The circle formed by this track is seventy feet in diameter.

This bridge is also noteworthy because it is located nearly five thousand feet above sea level. It is a portion of what is known as "The Mt. Lowe incline railway," a line which winds its way up the side of Mt. Lowe. The turn seems to show how crooked is this three-mile line.

Loading Lifeboats Safely on the High Seas

A canvas gangway let down from the side of a ship, and supported on floats, is designed to allow the loading of passengers without the danger of smashing the boats against the ship's side—an accident very apt to occur

Wireless Telephoning Simply Explained

By John L. Hogan, Jr.

NOT long ago newspaper readers were surprised to learn from newspaper headlines of the startlingly successful transmission of wireless telephonic speech from Arlington, Va., westward over the entire North American continent to Mare Island, California, a distance of two thousand, five hundred miles. This was astonishing enough, but when the next morning's papers reported that human speech had been transmitted wirelessly as far as Honolulu, Hawaii, about five thousand miles of land and sea, the earlier result was completely eclipsed. Later still, Arlington talked wirelessly with the Eiffel Tower in Paris, across the Atlantic Ocean.

For the past two or three years wireless telephony has not been largely advertised; in 1908 and 1909, however, its possibilities were greatly over exploited. As a result of the absence of publicity since about 1912 the new accomplishment of talking four thousand, nine hundred miles comes before us as an indication of a radical change from former methods of wireless telephony; the inference is that, since the distance covered is great, some real change of principle has been made. Nothing could be farther from the actual fact; wireless telephony in its earliest days was effected in exactly the same way as it is today. Increases in distance have come mainly as a result of using more powerful sending instruments and more sensitive receivers. The development of these devices is a matter of great importance, and has been a tremendous undertaking. Nevertheless, it should be remembered that wireless telephony itself is not a new thing. The transmission of articulate speech by modulated ether waves of the sort used in wireless telegraphy has been accomplished many times since its inception in 1900 or thereabout; radio-telephony, as this modern sort of "wireless" is officially named, began some fifteen years ago with poor communication by simple words over a distance of approximately one mile. The speech as first received was masked by interfering sounds, much as on a noisy telephone wire, but the defects were eliminated one at a time, until, in 1906, it was demonstrated that over distances of some twelve miles wireless conversations were clearer and better than those held over wire. The next year radiotelephony was demonstrated as an operating possibility when Fessenden wirelessly transmitted speech from Brant Rock, near Boston, Mass., to New York and Washington, distances of two hundred and four hundred miles respectively.

What Is Wireless Telephony?

The interest aroused by the new work of the American Telephone and Telegraph Company, whose engineers are largely responsible for the development of the specific instruments used in telephony from Arlington to Honolulu, has caused much speculation as to what radiotelephony really is. The idea of sending articulate sounds for miles over a wire and then reproducing them seems weird enough, but when the same process is accomplished without any visible connecting medium, except the earth, the result seems more than ever mysterious. Yet when one understands the natural laws which are applied in transmitting speech electrically, one seems no more marvellous than the other. Speech itself is not looked upon as wonderful, yet the mechanics of articulate sound are little less complicated than those of telephony.

To understand the real action of wireless telephony it is necessary to realize what speech itself really is. Vocal sounds, like all others, are produced by mechanical vibrations which reach the ear (usually through the air) and there cause similar vibrations in an auditory system, thus producing upon the brain the sensation of sound. In the production of speech waves, air is expelled from the lungs and, passing through the vocal system of the throat and mouth, is set in vibration. Nervous control of the organs of speech permits us to alter the vigor and frequency of the air-vibrations produced, and to combine the various frequencies of vibrations as we ma

choose. This faculty gives us the ability to signal to our neighbors according to the conventional sound-code called "language." In considering this it must be noted that the air lying between a speaker's mouth and an auditor's ear does actually move with the energy of the speech waves. The motion is not that of a current, for the air particles do not pass the entire distance from speaker to hearer, but is rather that of a series of impacts between successive molecules of gas in the atmosphere. In case a simple clear tone is sung, all the molecules oscillate back and forth according to a simple law of vibration. Each one strikes its more distant neighbor and, giving up its energy to it, then rebounds against that by which it was impelled in the first place. When the sound wave to be transmitted is complex, such as that representing a consonant (the letter B, for example), the path traveled by each molecule is also complex; the movement of the particles may be predetermined accurately, nevertheless, by adding together all the component frequencies of vibration which go to make up the sound being transmitted. It is this actual movement of each molecule, with exact fidelity to the vibration which set it in motion, that makes possible the transmission of speech by electricity in either the wire or the wireless telephone.

How the Ear Hears

Since sound-waves travelling in air are based upon a purely mechanical motion of the air particles, it is evident that it should be possible to secure a similar mechanical vibration in any body upon which the air waves strike. And this is what happens when a sound wave reaches the ear. The small diaphragm forming the ear-drum is set in vibration with the same frequencies as those which caused the sound-wave.

This ability of the air-waves to produce motion is not confined to effects produced upon the ear-drum, however; any diaphragm offered to them will vibrate in exactly the same way. The motions of such a diaphragm may be registered upon a wax record, as in the phonograph, and the original sounds thereafter reproduced by reversing the ...rding process and causing the record to move the diaphragm through its original series of paths. Or the motions of such a diaphragm may be used to change the intensity of an electric current, so that the sound variations in the air may be impressed upon the apparatus connected at the distant end of a wire, through the medium of electricity. When the variations in the electric current imposed by the action of the voice are caused to move a diaphragm at some connected point, and force this diaphragm thus to reproduce the original speech waves, wire telephony is accomplished. If the electric current which is modulated or altered in accordance with the original sounds is caused to set up radiating electromagnetic waves in the ether of space, and if these pass to a distant receiving station and there reproduce their original vibrations by causing identical movements of a receiving telephone diaphragm, radiotelephony is effected.

The three processes of speech transmission, viz., mechanically through the air, and electrically by wire or by wireless, are identical in the basic principle that sound vibrations are impressed upon some medium capable of carrying them to a receiver, and there are reproduced. The electrical process is merely a little more complicated by the interposition of a traveling electric current in a wire, or a traveling electromagnetic wave in space. These constantly connect the transmitter and the receiver, and, by changes in character produced by the original sound waves, reproduce their motions at the telephone held to the listener's ear.

The Essentials of a Wireless Telephone Apparatus

The wireless telephone, then, requires three important elements for its operation. First, there must be a generator of a continuous stream of electromagnetic waves which pass from sending to receiving stations constantly and upon which speech vibrations can be carried. Second, there must be an instrument which will modulate this stream of waves according to the voice vibrations to be transmitted. Third, there must be a receiver which will reproduce accurately the variations in the waves and so make

The powerful radio telegraph transmitter at the Arlington Station, near Washington, by which the human voice was carried to Honolulu and Paris

audible the sounds which are acting upon the modulating apparatus.

It happens that the generator has been developed to a high degree in connection with work on wireless telegraphy, and that there is now available for the radio-telephone far more wave-energy than it has been found possible to control by speech. In fact, this condition has existed from almost the earliest days of wireless telephony. Fessenden's sparks and arcs of 1903, and his alternating current generators of 1906, Poulsen's hydrogen arcs of 1907, and the later arcs, alternators and spark systems of other investigators, including Goldschmidt, Lepel, von Arco, de Forest, Majorana and Joly, have all been capable of generating more powerful streams of waves than it has been possible to control efficiently. Similarly, the receivers as used in modern wireless telegraphy have more than sufficient rapidity of response and delicacy to reproduce speech waves transmitted by wireless. Further increases in their sensitiveness have been made recently by the addition of amplifying relays to magnify the received sounds, but in every case this increase in sound strength has been accompanied by a disagreeable magnification of disturbing sounds from atmospheric interference which has prevented commercial use of the over-delicate instruments. The real limit of radiotelephony has therefore been in neither the generator nor the receiver, but in the modulating apparatus. It is in the development of this part of the transmitter that the engineers working under Mr. Carty of the telephone company have done their finest and most effective creative work.

The Eiffel Tower, Paris, where the great French wireless receiving station heard the voice in Washington, more than three thousand miles away across the Atlantic. Unfortunately the experiments between Arlington and Paris could not be continued. The Eiffel Tower is so essential in war that the French government has been compelled to abandon its interest in the work

The Bell System Aids the Wireless Telephone

As President Vail said: "So far as the perfection of the wireless telephone goes, there has been no new basic invention, merely a perfection of sending and receiving instruments. Of course, in the perfection of these delicate machines there have been minor inventions." The work of the telephone company on radio, following the inauguration of transcontinental telephony by wire, has been carried forward a step at a time for nearly a year. Speech was first sent from an experimental station at Montauk Point to the New York offices, then two hundred and fifty miles to Wilmington, and then one thousand miles to a specially erected station off the Southern coast of Georgia.

The results of these trials were more than enough to indicate still greater possibilities for the apparatus developed in the course of the experiments, and therefore arrangements were made to borrow the antenna of the great Naval Radio station, at Arlington, Va. The new type of transmitter was installed there, and preparations made for radiotelephony over longer distances. On August 27 a successful test was made from Arlington to Darien, Isthmus of Panama, two thousand, one hundred miles away. On September 29, in the early afternoon, speech from New York sent to Arlington, by wire, was relayed to the radiotelephone and transmitted to San Francisco, by wireless, over two thousand, five hundred miles. At the same time the talking was heard at San Diego, California, two thousand, three hundred miles away, and at Darien, Panama. Soon after midnight the engineers listening at a newly installed receiving station near Honolulu, Hawaii, reported that they were receiving portions of the speech direct over the four thousand, nine hundred miles separating them from Arlington, and that, although the words were very loud, they could be understood only when atmospheric and other disturbances were slight.

Tower at Arlington, Va., from which the wireless telephone reached Hawaii and Paris at the same moment

What's the Good of the Wireless Telephone?

The practical utility of radiotelephony has been much discussed. Generally it is believed that the wireless telephone has at least two fields of service, which are peculiarly its own, to wit, inter-connection of ships and isolated points on land, where it is not economically possible to employ a telegraph operator, and in conjunction with wire telephones as long-distance "trunk" lines.

The special feature of the wireless telephone is the freedom from distortion with which it transmits speech, and this, taken with its elimination of line maintenance expense, indicates a commercial future for the method when the apparatus shall reach a point of sufficient development. The engineers of the telephone company are to be credited with aiding the commercial development of the wireless method. It was largely due to their fine experimental investigations that the magnificent feat of communicating by articulate speech from Arlington to Honolulu and Paris was accomplished.

Oregon's magnificent highway, extending for two hundred miles through the heart of the Cascade and Coast Ridge Mountains, was built by engineers who first spent months in Europe studying famous mountain roadways there. The roadway is nowhere less than twenty-four feet in width and has a grade not exceeding five percent at any point. It is built to last for ages and is considered one of the finest examples of good roadmaking to be found in the country. In the circle above is shown a loop in the road affording a wonderful outlook over the Columbia River, on which the road opens vistas from time to time as it curves through the hills

Oregon Built a Scenic Highway for Motorists

A blind man listening to a printed page with the aid of the Phonopticon. Dr. F. C. Brown, the inventor, is operating the "eye" at the left of the picture. In the insert is a musical scale showing how the word "Law" would sound on a three-note Phonopticon

Seeing With Your Ears

Dr. F. C. Brown, of the University of Iowa, has provided the means of giving an eye to the blind. With his apparatus, the peculiar property of the chemical element, selenium, which causes an increase in its electrical resistance when the light falling on it is decreased, can be harnessed to the production of sounds which correspond to printed letters and which are created, not by a special device, but merely by moving the selenium "eye" across a printed page.

The principle is not new, for in 1913 Fournier d'Albe perfected an "Optophone," in which he used a simple selenium cell to translate printed characters into audible but hardly coherent sounds. The full development of the idea waited upon the isolation of selenium crystals of sufficient size and sensitiveness. For the past ten years Dr. Brown has been experimenting and has just produced selenium crystals, appreciable to the naked eye, which are one hundred times as effective as the selenium cell of d'Albe.

The actual "eye" of the Phonopticon, as Dr. Brown calls his apparatus, consists of an indirect illumination and a lens through which the light reflected back from the printed paper passes to the selenium crystals. It is so adjusted that the diminution of light caused by the passing of a black letter under the "eye" increases the resistance of the selenium crystals (which form part of an electric circuit) enough to deflect a portion of the current by a Wheatstone bridge to the segmented brass wheels which interrupt the current and so modify it, on the principle of the telephone, that it takes definite sound forms which corre-

spond invariably to the same letter forms.

As now constructed, Dr. Brown's machine consists of two sets of selenium crystals and two wheels, translating into sound the upper and lower portions of letters. When the Phonopticon is perfected, it will have three and perhaps four sets. At present the simple letters are easily distinguished by 90 per cent. of the blind persons who have used the Phonopticon. The letter V, for instance, is represented by a sound like *Mi Do Mi*, and the letter L by *Mi* and *Do* sounded together, with *Do* continuing alone. With three notes in his apparatus, Dr. Brown expects to handle practically every letter, though four may be needed for S and K.

The principle seems to Dr. Brown to be capable of unlimited development, even, perhaps, to the perception of pictures by means of some yet undeveloped use of the unique property of selenium crystals.

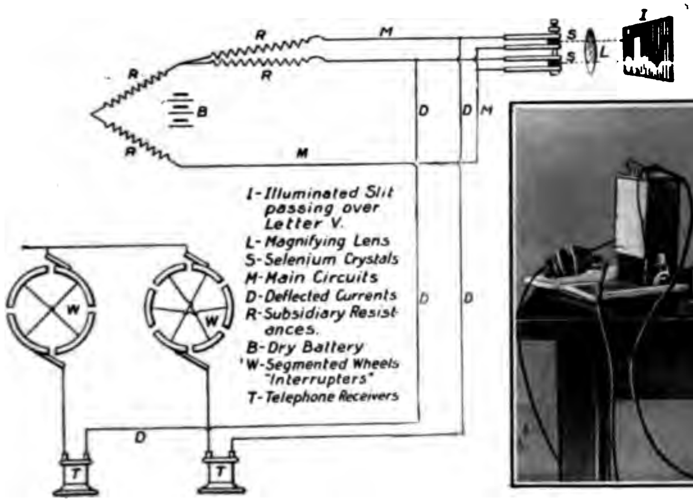
No Legal Damages for Canal Slide

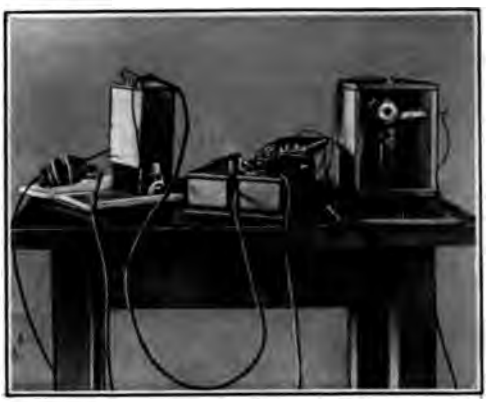
The United States government is not to blame for damages caused by slides in the Panama Canal, according to Judge Charles M. Hough, of the Federal Court of New York. The steamship *Newport*, of the Pacific Mail, was sunk at Balboa in August, 1912, by a slide which undermined the wharf, dropped eighteen thousand tons of earth, and hurled down on the ship two great cranes. The owners sued the government for eight hundred thousand dollars damages, claiming that the wharf was faulty, being badly built, and having been rotted by dredging, sea worms and other causes.

Chief Engineer George W. Goethals stated that the damage was due to a slide which could be neither foreseen nor prevented. Judge Hough affirmed this opinion and awarded the decision to the government.

For Aerial Coast Defense

Maine has the distinction of being the first state where actual steps have been taken toward the founding of a system of aerial coast protection. Rear Admiral Robert E. Peary, the discoverer of the North Pole, has offered to give the Aero Club of America the use of Flag Island, a position of strategic importance. The proposed aeroplane station would involve an expenditure of about ten thousand dollars and would include a complete equipment of one aeroplane, one hangar, two aviators, two mechanicians, and enough equipment to last for one year.



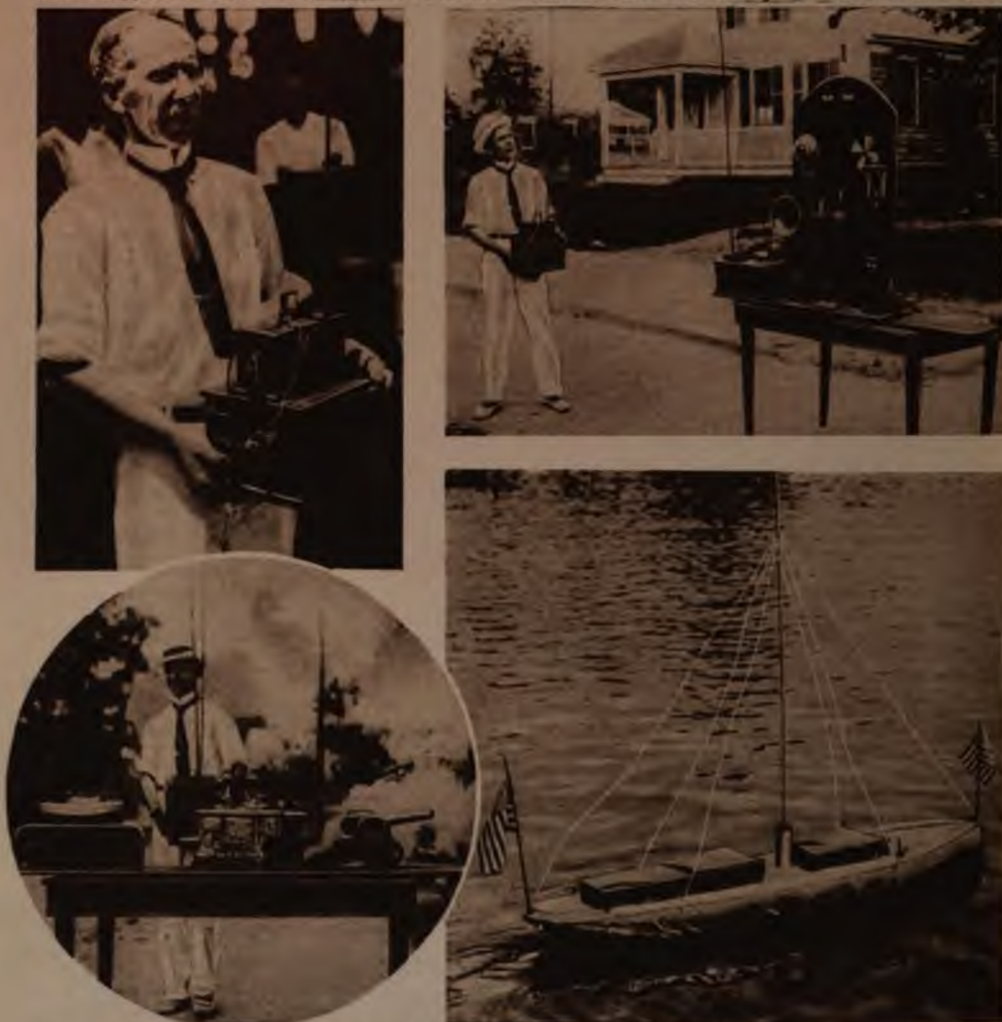


In the diagram the "eye" is passing over the printed letter "V," on which light is thrown. The rays pass through the lens L, the top and bottom of the illuminated space striking the two selenium crystals SS, which are part of the main circuit MM, increasing the resistance so that the current is deflected by the Wheatstone bridge to the deflected circuits DD, and thence to the segmented wheel interrupters WW, where the varying electrical current is transformed into sound heard through the telephone receivers TT

Steering Boats by Wireless

AT the very beginning of wireless telegraphy, even before Marconi's invention was developed into a form anything like that known today, it was suggested that boats and torpedoes could be guided and guns could be fired by the action of electricity without wires connecting the controlling and controlled stations. Tesla worked out numerous schemes whereby surges of current through the earth or along the surface of the ocean would be used to steer, and even *to supply* power to propel vessels at sea.

In the United States Patent Office there are a large number of specifications for various instruments and combinations of apparatus for effecting this general result, and many inventors have attempted to solve the problems which are involved. Admiral Fiske, U. S. N., devised a number of arrangements for directing torpedoes from a distance; J. H. Hammond, Jr., has demonstrated a system of wireless control developed at his Gloucester laboratory and applied to the steering of vessels over distances as great



These photographs show the wirelessly controlled devices designed by Professor Shepherd. The apparatus renders it possible to light electric bulbs, ring a gong, start an electric fan, blow a whistle, and run a little boat—all by wireless

as ten or fifteen miles from the "master" station.

The present European war has stimulated interest in devices of this character. Germany is credited with having produced an aerial torpedo, which is despatched toward an enemy encampment from a Zeppelin, directed toward the exact spot desired, and, on its arrival there, exploded by wireless. An aerial weapon of this type, if developed to a thoroughly practical point, would, of course, be extremely valuable, both in offense and defense; the ability to guide the torpedo after it has been sent out makes accurate preliminary aiming unnecessary, and the controlling airship may remain at a safe distance.

The construction and operation of wirelessly controlled devices, however, is by no means a simple matter. In radiotelegraphy, it is sufficient merely to signal dots and dashes, or time intervals, and no harm is likely to result from a momentary confusion of transmitted impulses. In radio-control, on the other hand, devices must be provided which will sort out the signals transmitted and produce specific results, according to the intention of the controlling operator. If, when it is desired to turn a wirelessly guided torpedo to the left, the receiving instrument so mixes the signals as to turn it to the right, much trouble may result. In order to prevent such mischances the instruments for radio-control, both at sending and receiving stations, are usually much more complicated than the apparatus which suffices for wireless telegraphy. The additional complexity introduces a greater possibility for accidental derangement, and so has long delayed the production of any thoroughly serviceable radio-control system.

There are several ways in which impulses sent from the same transmitter may be made to produce any one of several effects at will. By making use of the principle of sympathetic resonance it is possible to assign each single "tune" or frequency of vibration to a specific result, and then, by sending signals on whichever "tune" is adjusted to give the desired effect, to produce that action. Another way is to arrange the receiver so as to select according to the number of impulses transmitted; for instance, a group of two short signals might always turn the radio-controlled boat to starboard, a group of three to port, and a group of four might be arranged to stop the propelling motor.

The photographs on the opposite page show the wireless control apparatus devised by Professor Shepherd in its demonstration form. In the first picture the inventor is seen carrying a portable wireless transmitter, having its batteries and control key in the lower box, a spark coil and spark-gap immediately above, and supporting a small sending aerial wire. The second and third photographs show the receiver, which is arranged so that a semaphore, a pair of electric lights, a gong, an electric fan, or a whistle may be operated by pressing the key at the transmitter. Similarly the motor of the small boat may be started, a fire ignited in the stove, or the cannon shot off. The fourth picture shows a model boat carrying its own aerial mast and wires, and arranged for wireless control.

Oxy-Acetylene Makes Great Saving in Paper Mills

A large paper mill in Maine threw away its broken and defective paper cores for many years before it discovered that all of them could have been made as good as new by oxy-acetylene welding. By this new method broken cores are now repaired in nine minutes. The two sections are prepared by being cut off in a machine with the regular cutting-off tool. During the welding operation they are slipped over an iron arbor of the same diameter as the shaft on which the roll is designed to run, to insure perfect alignment with the longitudinal center. As these cores accumulate very rapidly in the enormous production of a large paper mill, it is stated that enough of the kind of material heretofore scrapped is now on hand to furnish several years' supply without drawing in the slightest on any other source of supply.

A French electrician has invented a telephone which is entirely concealed within the limits of a flower vase.

The Electric Dog and How He Obeys His Flashlamp Master

By B. F. Meissner

The electric dog and its master. A pocket flashlight is the magic wand which it obeys

THE electrical dog, which Mr. John Hays Hammond, Jr., and I designed, and which has received much publicity, has no tail to wag and no voice to bark with, but he can follow a person about in a most surprising way.

Like the sunflower that follows the sun in its path across the heavens, my first apparatus was capable of turning itself only to face the object that stimulated it. But a great difficulty had to be overcome. The stimulant was light, and sometimes the dog saw too much light, so that he behaved occasionally in an astonishingly erratic manner.

Just how grave a difficulty this disobedience really is, was illustrated by an amusing incident during a demonstration at a Chicago theater.

The dog was ready to spring into action, but when the stage was lighted, instead of obeying the flashlight held in my hands, the dog insisted on paying attention to a very alluring but not thickly clothed young woman painted on the scenery near by. It seems that the reflected light from the painting was sufficiently brilliant to compete with the flashlight and to cause the dog to creep to this fairer attraction with a directness which was almost uncanny.

To all practical intents and purposes, the electrical dog is a dead dog until excited by an external light ray—usually a pocket flashlight, held in the hand. Fastened to the front of a squat, oblong box on three roller-like wheels, are two great lenses, much out of proportion to the rest of the dog's make-up. These are the eyes through which the dog receives his intelligence. Behind the lenses are two extremely sensitive cells containing the black, wax-like selenium. Because of the importance of this substance in the dog's behavior, the mechanical animal has received its nick-name, "Seleno." A peculiarity of selenium is that it is sensitive only to light rays; or, to put the facts a little more technically, selenium is a non-conductor of electric currents until it is struck by light, when it becomes a conductor. Located behind the selenium eyes is an arrangement of relays, batteries, magnets and a motor. When a beam of light strikes one of the selenium cells, it causes a relay to be operated which, in turn, causes current to flow through one of the magnets controlling the steering wheel. The driving motor starts, and the dog is under way. Shift the light so that it strikes the other selenium eye and the dog moves in the other direction. In other words, in whichever direction the light travels, there, also,

will the dog go. By reversing a switch on the outside of the box, the dog can be made to back away from the light. Illuminating both cells equally causes the dog to move in a straight line.

The electrical dog will never become a common household toy. It has taken years of scientific study and endeavor to perfect, and it requires ripe technical knowledge to understand clearly. However, for the benefit of the reader who possesses more than an average amount of scientific and technical knowledge, a detailed description of the electrial dog is given in the following lines:

The mechanism involved in the successful performance of the electrical dog is so complicated and delicate in its nature that it is doubtful if many experimentors will care to attempt its construction. Few dimensions are given, because the materials naturally convenient to the builder have an important bearing upon even the most detailed parts of the apparatus. The dimensions, together with the construction in general, are largely a matter to be determined by the builder's individual ingenuity. The general construction details supplied here were embodied in the electrical dog, or orientation mechanism, that Mr. John Hays Hammond, Jr., and I constructed, and which I have employed in lectures and demonstrations before various engineering societies and gatherings of all kinds.

Beginning outwardly, the electrical dog has these three dimensions: Length, three feet; height, one foot; width, one and one-half feet. A small shelf projects from the bottom of the box towards the front. This is sawed or whittled almost to a point, and a metal plate erected extending four or five inches outwards from a line drawn exactly between the lenses. The plate is there to prevent light from going into one lens when it is intended for the other.

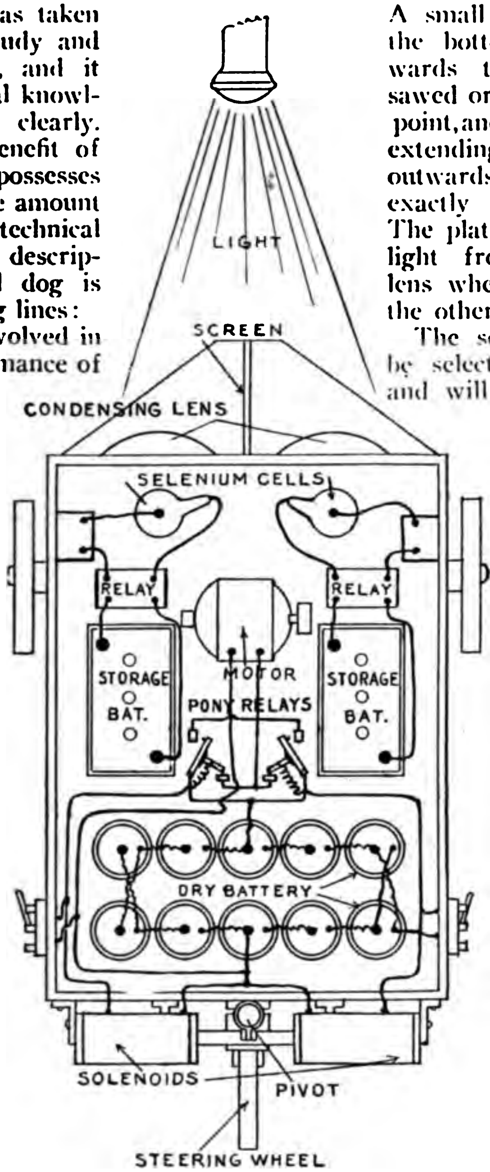


Diagram showing the electrical apparatus used in the construction of the Hammond Meissner Orientation Mechanism, or Electric Dog. Rays of light striking the selenium cells cause the motor and steering magnets to be operated. The light in the position here shown causes the dog to go in a straight line

The selenium cells should be selected with great care, and will cost from five dollars apiece, upwards. The cells are of as low a resistance as possible, this resistance being at the same time consistent with a high resistance ratio between light and darkness. Putting this thought into concrete figures, cells with a resistance of from one thousand to one hundred thousand ohms normal or "dark" resistance are the best. The resistance of the cell in the dark should be at least three times as great as its resistance in sunlight. I have used cells of sixty thousand ohms resistance, and they gave good results with batteries of fifteen or twenty dry cells. Since the current amounts to

only a few thousandths of an ampere, small flashlight batteries may be employed. The selenium cells should be capable of carrying at least two or three milli-amperes without heating.

The next and probably the most delicate step in the entire construction is the ultra-sensitive relay that is placed in circuit with each selenium cell. These should operate reliably on a change in current strength of as little as twenty-five millionths of one ampere.

The finest of polarized relays, such as those devised for use with coherers in the early stages of wireless telegraphy, require an operating current of at least five hundred microamperes, or one-half a milli-ampere; the most sensitive galvanometer relay with solid contacts requires about two hundred microamperes. These values are for conditions of jar and vibration such as those which naturally exist in the electrical dog. The relays that I use are the most sensitive of the pivoted, galvanometer type; but instead of having two solid contacts of platinum, one is made of platinum with a needle point, and the other is a globule of mercury, an arrangement which requires a very small contact pressure for reliable operation under vibration.

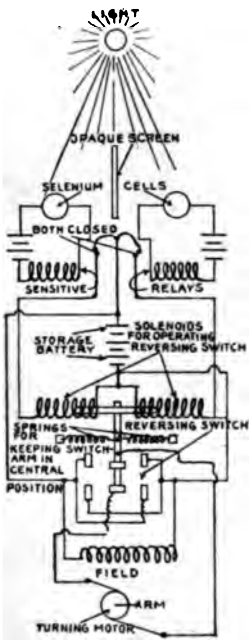


Diagram of the electrical connections

A drop of light oil over the mercury prevents oxidation. This contact, however, cannot break currents in excess of a few milliamperes and should therefore be used in conjunction with relays of the telegraph type, which are capable of handling the currents required in the motor and solenoid circuits. Less sensitive instruments cannot be used unless the source of light be very powerful. The sensitiveness of this arrangement is so high that a dog can be operated with ease from a distance of twenty feet with a pocket flashlight.

The pony relays indicated in the diagram are ordinary telegraph relays of twenty ohms resistance, provided with a special pair of back contacts, which are always closed when the relay is not energized.

The motor is a ten-volt battery motor of the largest size obtainable (about fifty watts). Its source of power should be a storage battery, which also supplies the solenoids. In my apparatus this battery was composed of four four-volt, thirty-ampere-hour cells. They should be as small and as light in weight as possible.

The solenoids are approximately five inches long and three inches in diameter, with cores three-fourths of an inch in diameter. Of the iron-clad type, they are wound with number sixteen magnet wire, and have cone-shaped pole faces, the air gap being inside the coil near the middle; the stroke is about one-half inch from the central position. Their purpose is to turn the steering wheel.

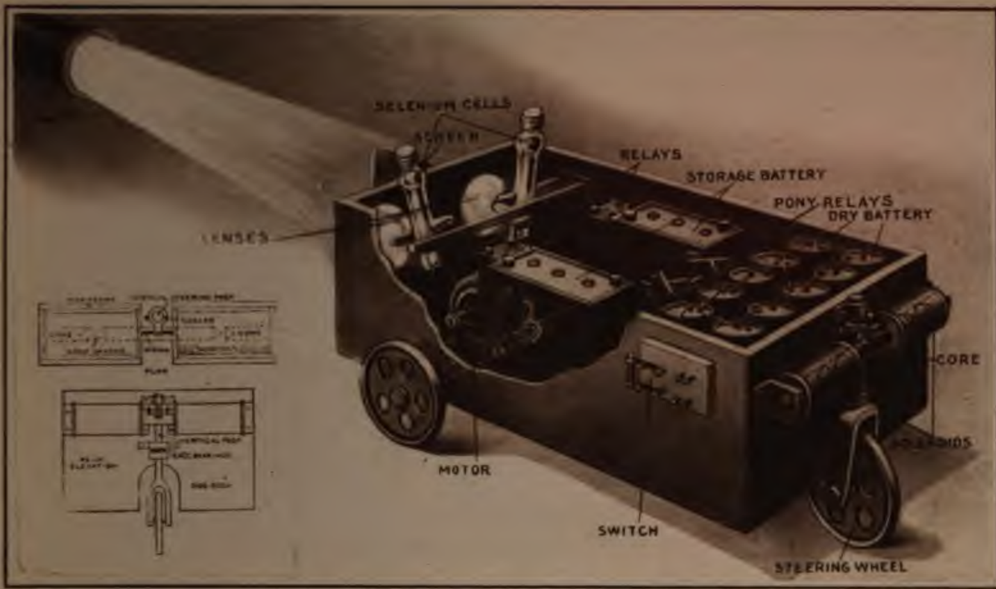
The core, which extends from one solenoid to the other, is maintained in the central position when both the solenoids are energized.

The single rear wheel is mounted on ball bearings in the horizontal plane to facilitate turning by the steering magnets.

The reversing switches, by means of which the dog can be made to back away from the light, instead of being attracted to it, are not shown in the diagrams as they would introduce an unnecessary amount of complication. Their purpose is to reverse the connections of the two solenoids.

The driving motor is connected to the shaft of the two forward wheels through a worm-wheel reduction, and a differential gear box, such as those on automobiles.

The adjustment of the parts of the dog is sometimes a rather difficult task, particularly when other sources of illumination besides the flashlight are encountered. If used in a room with windows through which daylight passes it



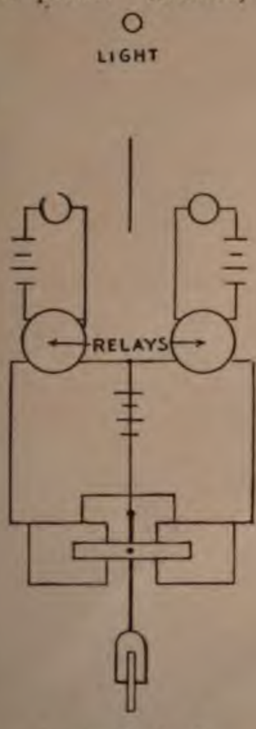
A perspective view of the dog showing his internal mechanism. In the insert, a diagram showing the construction of the steering solenoids

may suddenly refuse all the inducements offered by the master with his pocket flashlight and turn his entire attention to the pursuit of the window.

The principal adjustment is that of equal sensitiveness of both selenium-cell-relay units. It is practically impossible to obtain two selenium cells having equal resistances and equal sensitiveness, and therefore different applied voltages and different tensions in the back springs of the relays are necessary, in order that both will operate at the same instant when influenced by the attracting light, and that both will release at the same instant when the light is extinguished, or when it becomes too weak to effect operation.

With selenium cells made sensitive only to definite colors or wavelengths of light, it is possible to make the dog back away with one light and be attracted by another. Cells can be given a certain amount of inherent color sensitiveness, but this is best secured by means of ray filters which allow only definite wavelengths to pass. Another means of making the dog sensitive to only one source of light is to cause that light to be interrupted by means of some form of shutter, in conjunction with selective elements on the dog which will not allow the sensitive relays to be closed unless the fluctuations in the transmitted light correspond exactly with the frequency of the selective element.

It is obvious that if we make the dog a boat instead of a wheeled vehicle, and if we provide the boat with a forward compartment filled with gun cotton, we would have a torpedo of the kind described and pictured elsewhere in this issue. A searchlight on board a ship would serve to guide the torpedo on its course of destruction through the water.



A simplified diagram illustrating the principle of the dog's construction

Hanging a Defective Boiler Plug as a Warning

A MINIATURE gallows from which hangs a defective fusible plug responsible for a boiler explosion which occurred on board the steamship Jefferson, near Norfolk, Va., on May 11, 1914, is one of the interesting curios on the walls of the office of Secretary Redfield, of the Department of Commerce in Washington. It is a grim reminder of a tragedy which cost the lives of eleven men. A small placard above it reads:

"A Murderer! Hung for killing eleven men."

Below it are the words:

"The fusible (?) plug which failed to fuse. From the boiler of the S. S. Jefferson. Boiler exploded. Eleven lives lost."

The plug consisted of a threaded brass bushing about an inch and a half in diameter, with hexagonal head. Through the center of the bushing runs a plug of fusible metal, which, in this instance, was defective; it did not blow out when the water in the boiler became low, thereby causing a disastrous explosion. When the plug was sawed open lengthwise it was found that most of the original filling had disappeared, only a few traces of it remaining embedded in a dirty, greenish-white mass of tin oxide, which would not melt until heated to a temperature somewhat higher than 2,900 degrees Fahrenheit.

Impurities of the fusible filling of this plug prevented its blowing out and resulted in the loss of eleven lives. So, the plug was hanged as a murderer, in a government bureau

Impurities in the fusible metal, which were the cause of its failure to blow out, are easily discernible. In subsequent investigations made by the United States Bureau of Standards ten hundred and fifty fusible plugs were examined. These were from one hundred and five different makers, and about one hundred of them had been in actual use for from four to twelve months. From a study of these plugs the Bureau recommends that the fusible metal itself should preferably be pure tin, because it has been found to be far more reliable and durable. The Bureau further recommends that the tin be as free as possible from zinc and lead.

One of the many types of deterioration of fusible plug fillings observed by the Bureau consists in the formation of a network of minute thread-like cracks or corrosion-regions, ramifying in all directions. The Bureau found that these penetrated the metal and then broadened out until the filling was largely, or wholly, oxidized and destroyed. The presence of small quantities of zinc in the tin was the main contributing cause of the network type of corrosion. This was proved conclusively by the investigation conducted after the disaster.

Why Do We Grow Bald?

Disease and tight hats are not the chief causes. Baldness can be inherited, like other traits

By D. Osborn, Ohio State University

IT IS popularly supposed that some forms of baldness are caused by the wearing of tight hats. Often the line of baldness seems to coincide with the hat-band, which might show that it is cutting off the supply of nourishment to the scalp. One of the main arguments in support of this theory is that women do not become bald.

In making a study to determine whether heredity is an important factor, I considered only pattern baldness. By pattern baldness is meant the kind associated with thin, normal or heavy hair. It usually does not put in its appearance until after the twentieth year. Among the various patterns the most common are complete baldness on the top of the head; that involving only the crown; that giving the appearance of an extremely high forehead, and that covering the top and back portions of the head.

Obviously the line of baldness here does not coincide with the hat-band

In one family the father was bald before he was thirty. His only son showed the same baldness pattern at birth, but later grew a normal head of hair, which he retained until the past year. Now at twenty years of age the hair is beginning to fall out in the same fashion that his father's did. This indicates that the baldness pattern may be plainly defined at birth.

In two families which were studied, no baldness whatever could be found. Heavy hair predominated and was retained to an advanced age. Tight hats were worn by the men, but neither the hats nor severe illness had affected the luxuriance of the hair.

The families which were traced in reference to baldness show clearly that it is inherited. Contrary to the prevalent belief, women do become bald. They are more sensitive concerning it and can more easily conceal it than men. However, there are fewer bald women than bald men, due to the method of inheritance. Pattern baldness is called a "sex-limited trait." The characteristic is transmitted directly from father to son and may be inherited through the mother, though she herself is not bald. A bald man may transmit the trait to his daughter, who though she does not show it herself can transmit it to her children. A woman of this type is called a carrier. If a woman inherits the tendency to baldness from both parents she herself becomes bald. Inheriting the tendency from both parents does not necessarily mean that both parents must be bald, but that the father is bald and the mother a carrier. A bald woman must inherit double the tendency that a bald man inherits.

That women may behave as carriers of baldness explains why it may skip generations and ap-

The man on the right is thirty-five years old. The one on left is fifty. The patterns of baldness are distinctly different

pear in a family suddenly. The carrier tendency can be transmitted from mother to daughter so that baldness itself might not show for many generations. In the long run half the sons of a bald man or a woman carrier will be bald and half of the daughters carriers. If the mother is bald all of the sons will be bald and all of the daughters carriers.

Illness will occasionally cause baldness in women when there is only the single inherited tendency. In a case of this kind not all of the sons will be bald. Where there is no tendency to baldness the hair may fall out from poor health, but afterward it is regained.

Father and daughter aged sixty and twenty-two. Both have luxuriant hair, although the father lost his in youth through fever

A Bicycle Which Won't Let You Lose Your Balance

AN APPARATUS has been invented by Eugene Tourtier, of Paris, France, which gives bicycles, motorcycles and every other similar vehicle a vertical equilibration regardless of whether or not the road is level. It is merely necessary to support the machine in an upright position by operating a lever attached to the handlebar.

The lever can be operated while the bicycle is moving, making it possible for a rider to remain in his seat as the wheel comes to a stop and to start again without dismounting.

The apparatus consists of two steel-rod supports pivotally attached to the rear frame of a bicycle or motorcycle, and a strong, flexible wire which leads from the supports to the lever on the handlebar. The supports may be forced downward as the bicycle moves, causing it to stop quickly and holding it upright and steady when it does stop.

The steel rod supports are strong enough to sustain a combined weight of eight hundred pounds

Cork Fabric for Featherweight Raincoats

CORK fabric is a recent French production, the result of a new French process. It is waterproof, a non-conductor of heat, and unbreakable. By using a special machine, thin slices of cork of an even thickness are obtained from a block of cork. The slices are placed in chemical baths in order to remove the resinous parts which make cork a more or less brittle substance. Upon their removal the cork sheets become flexible and may be compared in this respect with thin leather. In fact, the sheets can be folded and bent without breaking.

By combining the cork sheets with any suitable cloth, preferably a thin and strong cloth of good color, an excellent waterproof material is obtained. An adhesive preparation is employed to glue the cork to the cloth; or, if a stronger garment is desired, the cork sheets are placed between two layers of cloth. The cork fabric has a decided advantage over ordinary rainproof materials because it is porous, permitting ventilation where the ordinary raincoat prevents it. Of course the cork is very light. A coat made of it is said to be the lightest on the market.

Brushing Your Teeth; There Is a Right and a Wrong Way

IF people as a whole were aware of the importance that a toothbrush plays in the healthful happiness of their entire body more attention would be paid to this perfunctory daily exercise. The soberness of this fact is perhaps a trifle more evident when it is mentioned that mouth infection is now known to be the source of numerous diseases that cause chronic sickness and eventually death. Looking upon the situation from the opposite side, it is equally true that mouth and

The teeth and gums should be scrubbed with a circular motion five or six times in succession

teeth cleansing is the chief means of preventing these diseases, and in many instances, curing them.

A Philadelphia physician, who has gone more deeply than usual into this question, points out that mouth washes are of no value in the presence of bacterial masses, unless these are removed once a day at least. In other words, the mouth should be thoroughly scrubbed daily.

This physician lays even more stress

The tooth brush should be small and the bristles short. The upper brush is similar to those usually bought. The lower brush is correct

upon the correct use of the toothbrush. He has calculated the antiseptic and

The spaces between the teeth should first be carefully cleaned with dental floss

curative results brought about by the the use of the toothbrush on a mathematical basis.

For example, the tooth brush being usually two inches long, generally reduces the movement of the bristles to a half inch, which is almost all taken up by springing and pivoting, so that the actual friction amounts to very little, if anything.

Therefore, considering that friction is a highly desirable factor, the ideal

It is most important that the circular brushing should extend as far back in the mouth as possible

tooth brush is one not over one inch and a quarter long with bristles not over a quarter of an inch in length. Bristles of this length will necessarily be stiff, but if the gums are soft and inflamed, a brisk rubbing is the best thing in the world for them, and will, in the course of a week or two, bring them back to a state of health again. The fact that the inflamed gums become sorer than usual during the first few days is an indication of self-poisoning, or autoinoculation, a condition and a result that should not exist in an otherwise healthy person.

Care should be taken to follow the curve of the gum with the entire face of the tooth-brush

Floss silk, so this physician has noted, is another great corrective for ailing teeth. The silk should be passed between teeth, across gums and drawn rapidly, even roughly. The discomfort may be slight, but it is sufficient to cause most people to avoid the practice, although they would perhaps be somewhat more enthusiastic towards this particular tooth cleanser if they knew that it would help greatly towards avoiding gout, rheumatism, valvular heart disease and ulcer of the stomach.

Concerning the general mechanics of tooth brushing, there are three important actions to be borne in mind. The first is the rotary motion, whereby all the gums and the teeth in front of the second molars are cleansed by a vigorous whirling motion. Second, the drawing motion wherin the middle of the brush is placed behind the wisdom teeth and drawn vigorously across the gums. Third, the drawing motion wherein the brush is placed back of the last molar and drawn sharply forward along the gum margins and the teeth.

It may be mentioned that healthy gums can stand the same vigorous friction as can be borne with impunity by the finger nails.

The middle bristles of the brush should be placed at the back of the third upper molar and drawn briskly forward along the gum margin

Hard-Pressed Germany Invents New Foods

POTATO sausages are being made in Germany which are said to taste a great deal like blood sausages, and are not a great deal lower in food value. The price of the potato sausages (called also K-sausages) is much less than the blood sausages.

It was found possible in Germany to purify bacteria-carrying oysters by allowing a stream of pure, fresh, filtered sea-water to run over them, in tanks, for four or five days. No sickness resulted from eating these oysters.

Study of the milk marketed in Zittau, Germany, up to the present time of the war shows that scarcity of good fodder for the cattle does not decrease the fat content of the milk, but only the quantity of the milk.

This movement will clean the backs of the teeth which are too often neglected

In Germany the comparative quality of the milk can be decided by the use of certain bacteria. Five are used, called respectively and alarmingly the "Danish streptococci," "Jaroslawer diplococci," "Gunthersehen diplococci," "Russian lactic acid streptococci" and "Bacillus bulgaricus." The Danish streptococci can live only in fairly good milk, the Jaroslawer diplococci in worse, and so on down the list until we reach the Bacillus bulgaricus, which is tough enough to live in very bad milk. However, there is milk so bad that not even the accommodating Bacillus bulgaricus can live in it.

An elderberry wine is being made in Germany which is so like grape wine that it can easily be used as an adulterant of grape wine. It can be detected by chemical analysis, however.

New methods for determining husk residue in meals and flours have to be used, since the German war orders to grind more of the husk into the flours.

The Indian's Conception of Angels and Devils

Below: Two totem poles which formerly marked the headquarters of tribes in Old Mangel, Alaska. To the Indians these designated a religious as well as a clannish bond

At left: A wooden mask carved and painted in the elaborate style dear to the heart of the Iroquois Indians and used by a false-face society

A typical ceremonial mask of the Iroquois. These masks, which seem only hideous, have a tribal significance

The mask on the right would doubtless frighten away any kind of a demon. It was worn by the medicine man

On the left: Another ceremonial mask less typically Indian but evidently meant to depict his enemy-friend, the white man

The Indians were especially fond of animal masks. To them they symbolized the kinship of man to his dumb neighbors

Telegraphing Through the Ocean

So that ships may avoid one another in a fog, Christian Berger converts them into huge violins which send out sound-wave signals

THE small-town American boy has a noise-making toy, which for simplicity, cheapness, and, above all, effectiveness, can hardly be surpassed. The principal components of the contrivance are: one tomato-can, one string, one lump of resin, and plenty of muscle in the small boy's right forearm.

Into a hole in the bottom of the tomato-can the string is run, a lumpy knot on its inner end preventing it from slipping completely through. This leaves a long, dangling cord when the ex-tomato-container is held outward in the boy's left hand. With his right he grasps the lump of resin and commences to stroke the string.

The harder he pulls the more distracting the noise

A responsive "ee-ee-eek" emerges from the mouth of the can at the beginning of the stroking process. Shrieks, cat-calls and strident, earsplitting wails can be made to follow the "ee-ee-eek."

In a sense the contrivance is not unlike a violin. The can is a resonator; so is the violin body. The string is rubbed to make a sound; so is the catgut of a violin. The fundamental principle involved is the same.

Curiously enough, a contrivance operating very much on the same principle has been found to be one of the most effective submarine signaling devices yet brought out. The machine in question is the invention of Mr. H. Christian Berger, a New York physicist. It has been put in successful service on a number of American vessels, some of them warships—despite its resemblance in principle to the tomato-can toy or the violin. It is the result that counts.

Mr. Berger's device employs either a narrow steel strip or else a piano wire as the vibrating member, this serving the same purpose as the string in the case of the can-toy or violin. One end of the wire is attached to a plate in the steel hull of a vessel, the other end being fastened to a similar plate on the opposite side, or else terminating in a framework affixed to a convenient beam. The steel plate in the side of the vessel acts as a sounding-board to send sound-waves out into the water, just as the bottom of the tin can sends waves into the air. Instead of a lump of resin in the hands of a small boy as the exciting agency for the vibrating strip, this contrivance employs a motor-driven rubbing-wheel, the felt-covered rim of which is the equivalent of a violin bow and is moistened with alcohol in order to provide an efficient rubbing medium. Although the motor which drives this wheel runs continuously, the wheel itself may be started and stopped at will by means of a telegraph-key controlling an electromagnetic clutch mounted on the motor-shaft. Thus a telegraph-key governs the sending of vibrations just as in wireless telegraphy.

In a few feet under water a bell's sound loses its characteristic bell-like tone

The question naturally arises: Of what use is a submarine signaling

Mr. Berger's device resembles in principle the tomato-can toy. On the other hand, sounds sent out into the water

The signals sent out under the water are picked up by a microphone in the vessel

device. Is it not enough that men can signal through air with whistles and lights, through ether with wireless telegraphy, and over wires with the aid of electricity?

The answer is this: Strong as men have built ships, as well as they have chartered the ocean, as many safety devices as they have installed on boats, one overpowering danger still confronts navigators. That danger is fog. In a thick fog it is almost impossible to see from one end of a boat to the other, let alone out over the water toward any approaching vessels. Sound-signals do not carry far in air and are most untrustworthy. Hence the frequent mishaps which occur when bell-buoys, or other sound warnings near hidden reefs are not heard. Signal lights, rockets, lanterns, and similar devices depending upon light are obviously inoperative in a fog. Wireless waves—usually so effective in warnings of sea dangers—have their limitations, too. Unless the operators carry on specific conversation as to their ships' positions and the danger of bumping into each other or into objects on shore, the wireless signals themselves carry no warning of impending disasters; the strength of wireless signals, as received, is no criterion of the sending vessel's distance.

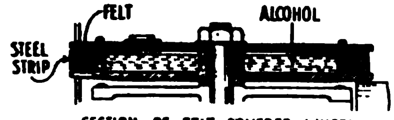
Hence when a fog descends over the sea, light signals are utterly useless, sound signals in air do not carry far and are uncertain, and wireless telegraphy is good only in certain instances. Is it any wonder that inventors have taken to investigating the possibilities of submarine signaling, all the more since they have discovered that sound-signals will carry long distances under water and are unaffected by fogs and storms?

by it can be made to have any sustained duration desired, so long as the felt-rimmed wheel rubs on the steel strip

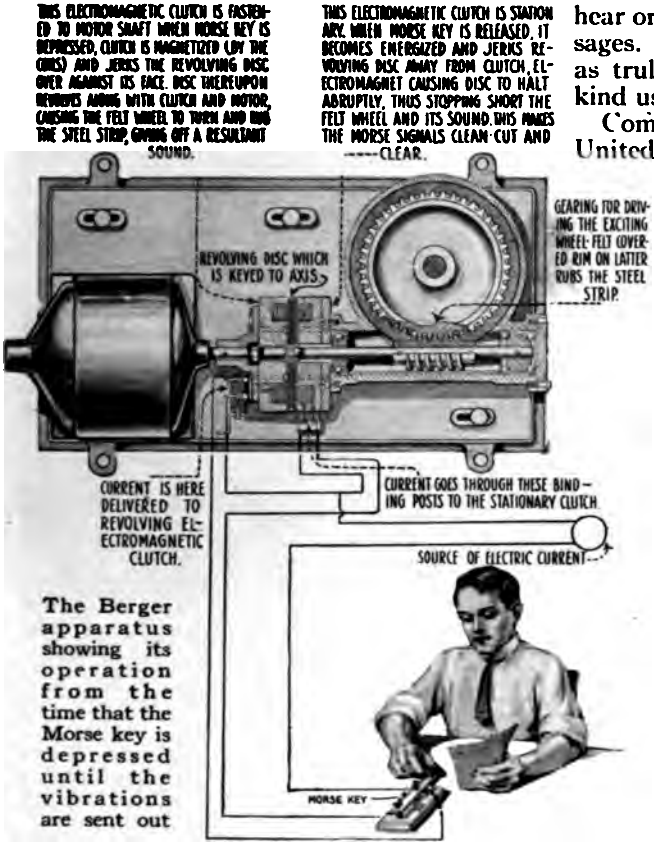
Vibrations from the interior of the ship's hull do not interfere with the signals

It is a queer world, this—down "under the sea." It might be supposed that no sounds at all can be heard under water. The opposite is true. Sounds carry better in a dense medium like water than in a comparatively "thin" gas such as air. All sorts of sounds can be heard under water—the throb of some distant ship's propeller, the pounding of engines, the explosion of distant mines, and hundreds of other noises. A microphone, placed in a chamber of water at the side of the receiving vessel and connected with a telephone receiver, aids in this hearing. Singhalese fishermen, however, have for centuries carried on communication between boats by the simple method of striking an earthen bowl *under* water, the listening fisherman placing his ear against the bare hull of his boat.

Submarine bells are already in use as fog warnings. Some attempt has been made to adapt them to the sending of Morse telegraph signals between one boat and another, as for instance between a warship and a submarine. The sound from submarine bells, however, does not endure; it is not sustained. In other words, one stroke on a bell sounds to the underwater listener just like any other stroke. All the strokes are short—have no duration. Since all the sounds are "dots," it is obviously impossible to send Morse signals, dependent on both dots and dashes (short and long sounds). Moreover, seamen who have listened to these underwater bells say that in a few feet a bell's sound loses its characteristic bell-like tone. The sound simply comes to the ears of the listener as a dull, leaden "click," something like that produced when two ordinary tablespoons or a knife and fork are struck



SECTION OF FELT-COVERED WHEEL



The Berger apparatus showing its operation from the time that the Morse key is depressed until the vibrations are sent out

together. Since all sounds come to the listener alike, it is obviously impossible sometimes for him to tell whether he is listening to a bell or to some strange noise of the sea.

Mr. Berger's submarine signaling device, however, has the one great advantage that sounds sent out into the water can be made to have any duration desired. As long as the felt-rimmed wheel keeps rubbing on the steel strip, a steady, sustained note is sent outward. As is explained in the illustration above, the rubbing of the wheel against the strip is under control of a telegraph-key, the sender operating this just as he would one on an ordinary electric telegraph circuit. As the first illustration on page 712 makes clear, these signals sent out into the water are picked up by a microphone (delicate form of telephone transmitter) mounted in a water-filled chamber in the side of the receiving vessel. The listener simply adjusts telephone-receivers to his ears and hears signals just as he would hear ordinary wireless telegraph messages. This sound-wave telegraph is as truly a wireless telegraph as the kind using electric waves.

Commander F. L. Sawyer, of the United States Navy, has proposed that the Berger invention be combined with ordinary wireless telegraphy, the two together forming an effective means of warning in case of fog. The fact that electric waves travel with the speed of light (186,000 miles per second), or almost instantaneously, and that sound waves in water travel much more slowly (4,708 feet per second), is the basis for the proposed method. The electric signals and the sound-signals are sent out simultaneously by the approaching vessels. The listener on either boat hears the wireless signal instantly and the sound-signal a few seconds later (it having taken that long to arrive) and he can judge fairly well how far apart the two vessels are—the number of seconds in this interval multiplied by the speed of sound in water giving the approximate distance. If the time intervening between receiving the two signals grows less and less the operators know that the two vessels are approaching and may collide. A code system, composed of different letters of the alphabet and indicating whatever course the vessels are pursuing, is also proposed.

Professor R. A. Fessenden has invented an underwater sound-signaling machine somewhat like Mr. Berger's. His contrivance, however, makes use of an electromagnetic oscillator working on one of the plates of a vessel's hull in place of Berger's vibrating wire. Both contrivances are effective means of communicating with submerged submarines.

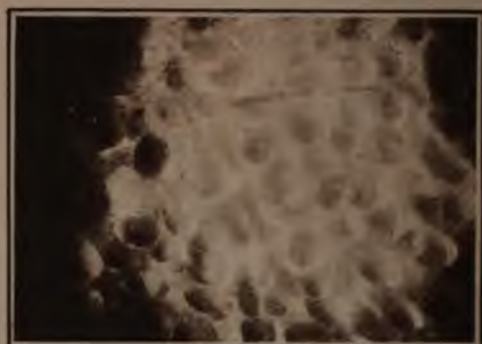
Cirrus clouds

Cirrus passing into Cirro stratus

Cirrus clouds

Alto-cumulus clouds

Cirrus clouds



Mammato-cumulus or "pocky" cloud

"*Mare's* tail" Cirrus clouds

A small form of Alto-cumulus

A Journey to Cloudland

A majestic cumulus, passing into cumulus-nimbus. A very beautiful and common type

THE clouds, like the stars, are among those common objects of Nature upon which men look, for the most part, with unseeing eyes. Some aspects of the clouds do, indeed, force themselves upon our attention—chiefly those that denote the imminence of a storm—but few of us realize to the full the beauty and scientific interest of the vapory pageant that is continually sweeping across our skies. Strange to say, many artists, skilled in painting landscapes, are unable to paint plausible sky scenes. About half a century ago an English painter, Elijah Walton, published a book (now almost forgotten) in which he pointed out that the great majority of out-door pictures, including those of the old masters, are very inaccurate in their skies. If the painter, whose business it is to observe Nature, has acquired so imperfect a knowledge of clouds, no wonder the average citizen needs instruction concerning them.

At first sight, clouds seem infinitely various, yet with a little study one can assign them all to a few broad classes. The scientific classification of clouds dates from the year 1803, when an English chemist, Luke Howard, published a description of seven cloud-types, to each of which he gave a Latin name. With a few additions and modifications, Howard's classification is now generally used by meteorologists. This system is based upon three fundamental forms: viz, fibrous or feathery clouds (cirrus), clouds with rounded tops (cumulus), and clouds arranged in horizontal sheets or layers (stratus). Intermediate forms are described by compounding the names of the primary types; e. g., cirro-cumulus, cirro-stratus, etc.

There is really no good reason why the intelligent schoolboy, who knows an oak from an elm and a crow from a turkey buzzard, should not be able to call the clouds by their names. The International Cloud Classification, now adopted for scientific purposes all over

Mammato-cumulus clouds

Cumuli with cirri-form appendages

Cumulus mammatus clouds

Alto-stratus clouds

Lenticular clouds

Cumulus, passing into strato-cumulus

A nondescript form of alto-cumulus

Nimbus (rain-cloud)

Anvil-shaped cumulo nimbus

Strato-cumulus clouds

world, is brief and simple, and must e as the point of departure in our irsion to Cloudland:

I. Upper Clouds

Cirrus ("Mares' Tails"). Detached clouds, delicate and fibrous, taking the form of feathers.

Cirro-stratus. A thin, whitish, often web-like sheet of cloud.

II. Intermediate Clouds

Cirro-cumulus ("Mackerel sky"). Small globular masses or white flakes.

Alto-cumulus. Rather large globular masses, white or grayish, partly shaded.

Alto-stratus. A thick sheet of gray or bluish cloud.

III. Lower Clouds

Strato-cumulus. Large globular masses or rolls of dark cloud, often covering the whole sky; especially common in winter.

Nimbus. Dark, shapeless clouds attended by rain or snow.

IV. Clouds Formed by Day in Ascending Air Currents

Cumulus. Thick clouds with more or less rounded summits and flat bases.

Cumulo-nimbus ("Thundercloud") The common cloud of summer thunderstorms; a mountainous mass, often turret-shaped or anvil-shaped, generally with a fibrous sheet spreading out above.

V. High Fog

Stratum. A uniform layer of cloud resembling fog, but not resting on the ground.

ie international Classification also recognizes a few minor types: especially *fracto-nimbus,* or "scud," (shreds of nimbus seen drifting under the rain-cloud); *fracto-cumulus* (small detached fragments of cumulus, undergoing rapid change in form), and *fracto-stratus* (formed when a uniform layer of stratus is broken into irregular patches by wind or by mountains). *Mammato-cumulus* ("sack cloud," or "pocky cloud") is a rare and striking cloud form, seen especially in thundery weather, consisting of rounded sack-like clouds, convex downwards.

The photographs accompanying this article will help the reader to interpret the foregoing descriptions. There are several collections of such pictures, known as "cloud atlases," of which the most important is the International Cloud Atlas, published in Paris, with descriptions in French, English and German. Equally useful, however, to the American student is the booklet entitled "Classification of Clouds," with beautiful illustrations in color, issued by the Weather Bureau and sold at twenty-five cents a copy by the Superintendent of Documents, in Washington.

The layman who has learned the cloud names given above will sometimes, perhaps, be puzzled to find a variety of other names applied to cloud forms by technical writers. The explanation is that many specialists have sought to introduce more elaborate cloud classifications; in which, however, the International nomenclature usually forms the substructure. None of these systems has ever come into general use.

Clouds are Composed of Tiny Needles of Ice

Turning, now, from the obvious to

the recondite, let us consider briefly the anatomy of a cloud. The highest clouds, cirrus, cirrostratus, and probably also true cirro-cumulus, with an average altitude of six or seven miles above the earth, consist of tiny needles of ice. All other clouds are composed of drops of water, and do not differ at all in structure from an ordinary fog, which is simply a cloud resting on the earth.

These cloud particles are formed by the condensation of the invisible water-vapor (water in a gaseous state) which is at all times present in the air. Just as water-vapor condenses and becomes visible on the cold surface of an ice-pitcher, so, it is supposed, condensation occurs in the free air on the surface of extremely minute (mostly ultra-microscopic) grains of so-called "dust," when cooled to the critical temperature with respect to the amount of water-vapor present (the "dew-point"). The exact nature of this "dust" is not fully understood.

You will perhaps wonder how clouds composed of water can exist in cold weather, when our ponds and streams are all frozen to ice; especially as it is a matter of common knowledge that the temperature of the air diminishes with altitude, so that wintry weather on earth implies wintrier weather in Cloudland. To find the clue to this enigma we consult the books on physics, and learn that, with proper precautions, it is possible to cool a liquid far below its ordinary freezing point (32 degrees Fahr. in the case of water). Clouds of "supercooled" water-drops are seen even in the polar regions. A sudden jar turns a supercooled liquid instantly to a solid; and thus it happens that, in cold weather, raindrops or fog particles turn to ice on coming in contact with terrestrial objects, such as trees, telegraph wires, and the like, giving us the interesting spectacle of the "ice storm."

Clouds are Always Falling

Another paradox is the fact that the bits of ice and drops of water composing the clouds should appear to "float" in the air, though of much greater density than the latter. As a matter of fact they do not. Cloud particles are all the time falling relatively to the air around them; though since this air itself may constitute an ascending current, they are not always falling in an absolute sense. The speed at which a cloud particle falls through the air depends upon its size; the smaller the particle, the more slowly it falls. The smallest have diameters of the order of .0004 inch and fall in still air at the rate of about a tenth of an inch per second. The largest range up to more than a fifth of an inch in diameter, and fall at the rate of about twenty-six feet per second. Raindrops and snowflakes are cloud particles which, in virtue of their size and other favorable conditions, succeed in falling all the way to the earth. Many a shower of rain or snow never reaches the earth, but evaporates in midair.

Reverting to the aspects of clouds as we see them from the earth, there are a few interesting phenomena that require notice. Cirrus and cirro-stratus clouds sometimes occur in long, narrow strips, extending across the sky, and, while really parallel, seem to converge toward two opposite points on the horizon on account of perspective. These strips are called "polar bands," or, popularly, "Noah's Ark." Parallel bands of cloud, whether in continuous strips or in separate cloudlets, reveal the presence of waves in the atmosphere. Where a wave carries a body of water vapor upward the latter cools by expansion and condenses to visible moisture. Thus the clouds mark the crests of the waves.

The "White Flag of the Chinook"

A kindred phenomenon is that of the "cloud cap" often seen over a mountain. Here the ascent of the air, with its charge of water vapor, is due to the upward deflection of the wind by the slope of the mountain. Sometimes the cloud cap, once formed, spreads far away to leeward of the mountain peak, constituting a "cloud banner." Such is the "white flag of the chinook," seen stretching from the crest of a mountain ridge in our Western states when the chinook wind is blowing over it. The same phenomenon constitutes the "foehn wall" attending the foehn wind in the Alps. One of the most famous and striking of

cloud caps is the "table cloth" that spreads itself over Table Mountain, near Cape Town, when a moist wind blows in from the sea.

Sometimes the local topography causes the wind that has swept up over the crest of the mountain to form a second "standing" atmospheric wave to leeward of the mountain, and this may also be marked by a cloud, which, like the cloud cap itself, presents a delusive appearance of permanence, while it is really in constant process of formation on the windward side and dissipation on the leeward. The pair of clouds thus formed—one over the mountain and the other at some distance from it—is exemplified in the well-known "helm and bar" of Crossfell, in the English Lake District.

Alto-cumulus clouds

Cumulus and alto-cumulus (above)

Of all clouds the most majestic are the mountainous masses of cumulo-nimbus that attend our summer thunderstorms. The formation of these clouds can often be watched from its early stages. On a hot, still day the warm air near the earth's surface streams upward by virtue of the same "convective" process that accounts for the draft of a chimney. The diminished pressure prevailing at higher levels permits the air to expand, and expansion causes it to cool. When the ascending column reaches a sufficiently low temperature, its water vapor condenses into cloud. The first visible stage is the appearance of a small cumulus, rounded above and flattened on the under surface, constituting the capital of an invisible column of rising air. This occurs at an average altitude of from four thousand to five thousand feet above the earth. In the course of the afternoon one sees these clouds grow and coalesce, until they have towered up to enormous heights; often ten thousand feet or more. Very often the summits become fringed with feathery ice clouds, called "false cirrus," but really identical in structure with true cirrus or cirro-stratus. Sooner or later the violent atmospheric circulation that produces these clouds culminates in disruptive electrical discharges, rain, and hail.

Similar clouds are not infrequently formed over great fires, and almost always over a volcano in powerful eruption. In the latter case an actual thunderstorm is commonly generated.

Apart from their shapes, clouds present interesting phenomena of color and give rise to a great variety of luminous appearances, including rainbow, halos, coronas, and the like. These yield much information concerning the structure of the clouds in which any occur. Thus halos occur only in ice clouds, rainbows only in water clouds. The corona (notwithstanding statements found in many books on meteorology) probably never occurs in ice clouds, though it is sometimes due to fine dust in the air. The colors of the rainbow, often described as invariable, really differ considerably from one bow to another, according to the average size of the water drops in which they are generated.

Beautiful iridescent colors may sometimes be detected in clouds, especially along their borders, and not pertaining to a true halo, corona, or rainbow.

st Comets and Their Story

By J. F. Springer

PERHAPS the most mysterious of all the heavenly bodies are the comets. Some are never seen except with the telescope, or else they appear as faint starlike bodies in the sky; others blaze forth, grotesque and fantastic of figure and brilliant in appearance, to excite and appal the ignorant. But always, whether dim or glorious, the appearance lasts but a moderate period at the most, and then the visitor is gone.

Astronomers make observations with instruments of precision and seek to follow the departed heavenly body by prolonging the ascertained path of its movement. And there has been a good deal of proved success in this work. For astronomers have in the case of some comets found that the orbit was a closed curve—an ellipse—and have thus been able to state in advance the time when and the place where a return would occur.

The most notable instance of a comet which continually returns is that of Halley's Comet. This remarkable body rushes through space in an elongated ellipse of such size that three-quarters of a century elapses between visits.

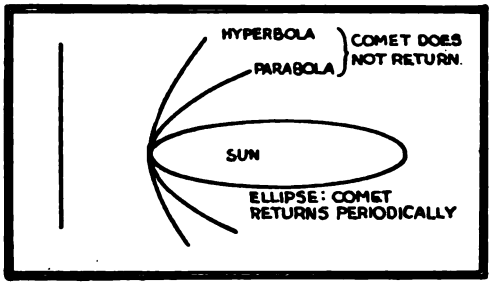
But there are comets which dazzle the sight for a period and then disappear never to return. Still others begin as regular visitors and then fail to reappear. Those comets which dart in from the outer regions of the solar system for a single glance at the earth and its inhabitants we are content to let depart without any especial concern. But when a comet makes regular visits and then disappears irrecov-

The comets blaze forth in fantastic glory occasionally exciting both curiosity and awe

erably, we are apt to feel perhaps that something has gone off from us whose place was with us. It is a case of a *lost comet.*

Thrown Off the Track by Jupiter

In the summer of 1770 a monstrously large comet appeared. Its apparent area was twenty-five times that of the moon. Astronomers made observations from time to time during its sojourn of several months. Difficulty was experienced in determining whether the comet was traveling in an open or a closed curve. If the orbit was an open curve, then there would be no reappearance as long as this character of orbit was followed. Finally, however, the astronomer Lexell succeeded in establishing that the comet was moving in an ellipse and that it should return in five and one half years. It is not known that this comet ever did really return.



Sir Isaac Newton proved that a heavenly body controlled by our sun moves in an ellipse, a parabola or an hyperbola

There was so much ascertained about its movements during its short stay that astronomers were reluctant to give up this comet of Lexell's. Investigation showed that, before its appearance in 1770, the comet had probably been forced into a somewhat different path from that which it had been following. In 1767, it had come within range of Jupiter's influence which may very well have modified its orbit into the curve noted by observation during the visit three years later. It was thought by Burckhardt, a French astronomer, that probably another passage near Jupiter had resulted not in creating a smaller orbit but in enlarging the ellipse. The new path that was calculated required the comet to reappear once in a period of sixteen years. However, the comet has never again been recognized. Lexell's Comet is for the present a lost comet.

In each of the years 1772 and 1805 a comet was observed. Again, in 1826 Biela, an Austrian officer, discovered a comet which was soon ascertained to be very probably identical with the comet seen in the earlier years. This body became celebrated from the fact that calculations showed that upon its next return in 1832 it would pass the orbit of the earth at a distance of only twenty thousand miles. A slight derangement of its orbit and it might approach more closely still. If the earth should be in the immediate vicinity at the time, then our planet's own attractive power would probably result in the comet coming into collision with us. The figures showed, however, that the comet would reach the region of close approach a month earlier than the earth. It seems, though, that it was a close shave. People at the time appear to have been stirred up over the possibilities. The comet came into view again at the period expected, but no untoward results occurred.

Forty years later, in 1872, the comet according to the astronomer, Klinkerfues, actually *came into contact with the earth.* He telegraphed to another astronomer his statement as to contact and suggested a search in a certain definitely named locality of the heavens. Here, the second astronomer actually saw *some* comet, but was unable because of unfavorable conditions to carry his observations very far. It is uncertain whether he saw Biela's Comet. If he did, then he was the last observer of that remarkable heavenly body.

Enough happened, however, in the forty years, 1832-1872, to lead us to think that very probably Biela's Comet has disappeared forever as a comet and that it is now a stream of comparatively tiny bodies. This statement requires explanation. In the first place, Biela's Comet broke into two separate parts, each becoming a complete comet. The two bodies traveled more or less closely together for a number of years. That there were two comets instead of one was first observed in 1846. Whlie under observation by astronomers at this time,

Halley's Famous Comet

This is Halley's Comet—the most famous of periodic comets—photographed at Yerkes Observatory during its last appearance. The stars in the background appear as straight lines because the camera was moved to follow the rush of the comet across the line of vison

the larger or more brilliant of the two was seen to have three tails arranged at equal angular intervals about it. One of these tails extended over to the smaller comet and formed some kind of connection with it. There was in fact a bridge of light between the two. The two comets were again seen in 1852, when they were still traveling along together. The interval between them, which was less than 200,000 miles in 1846, had now increased to 1,270,000. The comet seems never to have been certainly seen since this occasion. But, what was certainly seen was a great shower of "shooting stars." These luminous meteors seemed to radiate from just about the point where the orbits of Biela's Comet and of our earth cross each other. The date of the star-shower was some twelve weeks later than the time when the comet itself should have made the crossing. What these facts, when considered in the light of still other information of an astronomical character, mean is probably this: After 1852, Biela's Comet broke up into small bits of matter. These possessed individually the onward motion of the comet and were held in restraint by the sun (and any nearby planets), so that the pieces generally followed the orbit which the comet itself had been pursuing. The result was a long stream of very small heavenly bodies. When on November 27, 1872, a part of this stream came within the reach of the attractive power of the earth, the separate bodies fell through our atmosphere. The friction of the enormously rapid movement resulted in heating them up to incandescence. These fragments of the original comet thus became luminous meteors or "shooting stars." In 1798 and 1838, there were notable showers of stars at times and places which were near the position and time calculated for Biela's Comet for those years. These showers, in contradistinction to that of 1872, seem to have preceded the comet, itself. In fact, putting everything together, there would appear to have been a stream of small bodies five hundred million miles in length.

The foregoing suggests that when a comet is lost, the real fact may be that it has burst into multitudes of fragments.

Another comet which belongs to the list of the lost ones was first discovered in August, 1844. Apparently, Di Vico was the first to get even a telescopic glimpse of it. However, the comet rapidly approached our neighborhood, so that it was not long until it was visible to the naked eye. Di Vico's Comet was found to be traveling in a closed, or elliptic, orbit of such a character that it would return once in every period of a little less than five and one half years. The next return would accordingly be in the early part of 1850. Unfortunately, the comet, if it really returned, was too unfavorably situated with respect to the sun to be seen. However, in 1855, conditions would be advantageous. But no comet was seen then. Nor has this body ever certainly been seen since.

What Became of the Comet of 1264?

One of the most notable of the heavenly bodies which have more or less title to a place amongst the lost comets is the comet of 1264. This body engaged the attention both of Chinese and European writers. In 1556, another great cometary vision was seen in the sky in Europe and in China. Astronomers who studied the available data concluded that the two were one and the same comet. Calculations indicated that the period of revolution about the sun was somewhere in the neighborhood of three hundred and two to three hundred and eight years. Consequently, this great comet should have reappeared in 1858 or within a few years afterwards. It has, apparently, disappeared forever. In the year 975, a great comet was seen whose course has been thought by one astronomer to have possibly been that of the comet of 1264 at that time.

It is of interest to note that a comet may disappear because its elliptic orbit has been deranged into a parabola or an hyperbola. Sir Isaac Newton showed that a body controlled by our sun moves in a curve which is some one of the sections of a cone—that is, either an ellipse, a parabola or an hyperbola. As the latter two are open curves, a comet which pursued such a path would go off into space never to reappear. A derangement of orbit from closed to open curve has doubtless happened often.

Suns and Worlds in the Making

By Frederic Campbell, Sc.D.

Late President, Department of Astronomy, Brooklyn Institute of Arts and Sciences

THE theory of Laplace is still generally accepted, that our solar system originally evolved from gas. Could we witness the process whereby this transformation was accomplished, how awe-inspiring it would be found! But our eyes are ever too close to the pages of the book; we are too near-sighted as well as too short-lived. Place us in some distant spot of the universe, where the light record of the creation of suns and planets has just arrived, and we could peruse it all, as we can a much belated letter. But, with reference to thousands of similar systems, that is just where we are. The story is just now coming in. We look today on the things of a century, a millennium, ago. Light traveling at the rate of one hundred and eighty-six thousand three hundred miles a second, requires more than four years to come from the nearest star, perhaps thousands and tens of thousands of years from the farthest Hence in every case we see not what is, but what was

Now, as we thus gaze into the depths of space, if we discover traces of any processes going on, we become actual witnesses of the processes. And if anywhere through space we behold great masses of glowing gas being transformed into solar systems like our own, then we have ocular evidence which even Laplace did not possess, that the solar system likewise emerged from a cloud of gas.

While thousands of nebulae have been discovered in the heavens, only two are visible to the naked eye, namely, the great nebula in Orion, and the great nebula in Andromeda. The former, estimated at two thousand times the diameter of the solar system, seems to be a great though beautiful mass of confusion. The latter, estimated at six hundred times the diameter of the solar system, appears elliptical as to figure, and confronts us with problems comparable with those of Saturn's rings when first discovered.

The condition of nebulae is not revealed until photography co-operates with the telescope, and, by means of exposures covering hours, obtains record of details of structure that would otherwise never be known. The spiral pattern of some few nebulae has ng been confirmatory of Laplace's nebular theory. But there has recently come in much evidence of the spiral character of other nebulae.

Photograph by Yerkes Observatory.

There are many such spiral nebulæ in the heavens This is the one known as Canes Venatici. It looks like a pinwheel. In a sense it is, for it is revolving at a dizzy speed—a speed a thousand times that of the earth. Here we see a world in the making

THE BIRTH OF A SOLAR SYSTEM

Photograph by Yerkes Observatory.

The great nebula of Andromeda is often taken for a star of the first magnitude, yet the telescope discloses it as a cloud or luminous gas, whirling on its axis in a plane at an angle to our sight, a mass of star matter in the process of becoming a whole solar system. When the process is completed, aeons hence, the system will be far vaster than our own. Although its speed is terrific, yet in the history of astronomy not the slightest change has been noted

The conclusion seems forced upon us that practically all are in a state of rotation, and are hence supplying the centrifugal force to throw off the rings which, Laplace taught, roll themselves up into planets revolving about central suns.

The very confusion of the mass in the great nebula in Orion suggests that some kind of motion has here been at work. Portions of the nebula may be lacking in illumination which might otherwise show it to be spiral, rotating in space. The fact that the spectroscope has recently demonstrated motion in this famous nebula confirms the suspicion that it is doing what we know that so many others are.

The spiral nebulae, of which so many are now found, may be divided into two classes, those that are seen edgewise and those that are seen flat. Those seen edgewise sometimes present little more than a central sun, not yet fully condensed, cleft laterally into halves, showing that something stands between their central portions and ourselves. This something is evidently a thin disc of matter surrounding a central sun, but whose extension far into space we are unable to see. In other cases, however, the thin disc is plainly visible, and it becomes more apparent, if the nebulae be viewed somewhat tipped, as it is considerably in the great nebula in Andromeda, the reason for its elliptical appearance being obvious.

That these gases take the flattened disc form instead of the globular is convincing evidence that they are rotating, the centrifugal force thus generated flinging their elements far outward.

Photograph by Yerkes Observatory

The Great Nebula in Orion is a mass of glowing gas which forms the middle star of the "sword" of Orion. Through its luminous body gleam stars far beyond it. Its confused mass is now generally believed to indicate that it, too, is in rapid motion

But, when opportunity is given to look directly down upon a nebula, there results startling evidence of its being in rotation. There is no other way of explaining its remarkable details of structure. Some look like the propeller blades of a motor boat; some appear like spinning wheels; and some are actually caught in the act of throwing off rings, which are seen condensing at certain centers, rolling themselves into planets, henceforth to travel around their suns. The great nebula in Andromeda gives striking evidence that it is working out another and a greater solar system than our own.

In short, it seems that, in studying the nebulae, we are being admitted to the very workshop of the universe, and are permitted to watch the actual process of turning out worlds. Nothing in the heavens is better fitted to fill the very soul with awe. As in the case of the "fixed stars," our lives are too brief, too feeble our eyes, to detect the actual motion. But science determines the unmistakable facts, and reasoning does the rest

A Natural Substitute for Eggs

A Southern cook has patented a substitute for pudding and cake eggs. Yams are boiled until they are completely cooked, after which they are peeled and cut into thin slices, baked in a slow oven until they are crisp, and then powdered. Two drops of rose extract are added to each teaspoonful of the powder. One tablespoonful of this composition is claimed to be equal to one egg in the making of pastry, cakes, muffins, etc.

Is Mars Alive?

The Seven Hundred Puzzling Canals and What They Mean

By Waldemar Kæmpffert

E. C. Slipher, of Doctor Lowell's staff, took this instrument with him to South America. The drawings of the "canals" made by Mr. Slipher with this instrument agreed in detail with those made at Flagstaff, Arizona

IT was in 1877 that the Italian astronomer, Schiaperelli, detected on the planet Mars those curiously straight lines which he christened *canali* and which have since been a bone of contention among astronomers. Later he also saw his "canals" double, very curiously, until they looked like parallel railway tracks—something which has not been satisfactorily explained to this day. Now that Mars is about to approach the earth again, a number of observers, headed by Professor W. H. Pickering of Harvard, are to add their opinions to the dozens which have been delivered in past years, all without materially affecting the validity of Schiaperelli's work.

Although Mars can never approach us nearer than thirty-five million miles (which is much nearer than it will approach in February), we know more about its surface markings, in some respects than we know about our own Earth. If the Earth were viewed as we view Mars, the only evidence of human handiwork that we could see would be the extensive grain fields of Canada and the United States. Of natural phenomena we would note the melting of the Himalayan and Rocky Mountain snows and the consequent flourishing of vegetation; the great caps of snow that cover the poles; the continents and oceans; and the clouds that girdle the Earth. If a Martian were asked to fathom the mystery of a planet of which he knew only these things, we would hardly expect him to form a very accurate conception of our animal and plant life or even of our geographical and physical conditions.

Far simpler is the task of the earthly astronomer who studies Mars. The planet is never obscured. No clouds, no veils of mist can dim the view; for the Martian atmosphere is ever dry, rare and severe, except around the melting caps. A weather prophet would have nothing to do on Mars. There is no weather—only the changes of the seasons.

Watching the Snows of Mars

Soon after the telescope was invented and used for astronomical observation it was discovered that there is snow on Mars. During each Martian winter great white caps settle down on the poles; during each spring and summer they dwindle and disappear. In the dead of winter these white expanses may measure thirty-three hundred miles in extent.

Besides the snow, astronomers long ago discovered that there are curious blue-green and russet areas on the planet. At a time when astronomy was not as advanced as it is now, the blue-green areas were supposed to be seas and the russet expanses continents, with the result that both were christened with picturesque but inapt names drawn from classical mythology.

Some years after Schiaperelli discovered the famous canals of Mars, Pro-

fessor Percival Lowell established at Flagstaff, Arizona, an observatory, equipped with the best instruments obtainable for the special study of Mars. He has gathered about him a corps of observers, who have become wonderfully skilled in refined Martian observation; he has the advantage of viewing the planet in an atmosphere unsurpassed for clearness; he has made his observatory the fountain-head of all important Martian discoveries. To him we owe our remarkably detailed knowledge of the planet's surface markings.

The Seven Hundred Canals—What Are They?

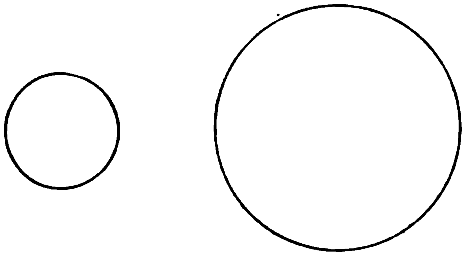
It was Professor Lowell who not only confirmed Schiaperelli's discoveries of the canals, but who plotted them accurately year after year and added to them until now their number is seven hundred and eighty-eight. It is he who originated and for more than twenty years has developed the theory that the canals are all that their name implies—artificial waterways constructed by intelligent beings. Perhaps it is because he has so persistently heaped one piece of evidence upon another to prove his theories that there is any Mars controversy at all. His opponents would probably be more inclined to accept the existence of the canals if he had not interpreted the markings of Mars in the way that seemed most natural and simple to him. It is certain that they accept without question the markings of other planets, plotted under the same conditions.

The distinguishing surface features of Mars are the snow caps at the poles, vast russet areas and blue-green regions between the poles, and the fine, straight lines which are known as "canals." Dr. Lowell holds that the straight lines are indeed "canals," and serve to conduct the water from the melting snows at the poles to the russet-brown areas, which are deserts, and cause them to flourish. Dr. Lowell's theory finds confirmation in the fact that portions of the russet-brown areas assume the characteristic blue-green hue of vegetation with the advent of Spring

The significance of the canals is apparent when it is considered that nowhere on Mars is there any water except at the poles. Ages older than the earth, Mars has arrived at a pitiful condition which may best be described as deadly aridity. Long ago much of the fertile area of the planet shriveled to an immense desert. Oceans, seas, and lakes leaked into the interior by way of caverns and crevices, leaving only parched basins. The atmospheric gases have in part floated away, so that the air has become as rare and as thin as we should expect to find it miles above the Rocky Mountains. Whatever water still remains, gathers in the form of snow or hoar frost at the poles.

Clearly, if Mars is inhabited, Professor Lowell argues, the one supreme task that engages the attention of every thinking being on the planet is the utilization of that pathetically scant supply of water. If it were possible to conduct the water of the melting snows in spring to those portions of the torrid and temperate zones that would still bring forth, if properly nourished, a race might save itself.

In the canals Professor Lowell sees the life-lines of the planet. They are to him great irrigating trenches which con-



The relative sizes of the moon and of direct Mars photographs are shown by these two circles. The size of the moon to the naked eye is indicated by the circle to the left; the circle to the right indicates the size of a direct Mars photograph before enlargement. This disposes of the usual contention that the Mars photographs made at Flagstaff are no larger than pinheads

duct the water of the melting snows to fertile fields thousands of miles away.

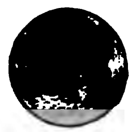
The Canals Are Irrigating Ditches

No more forcible argument in favor of this view can be advanced than their appearance and arrangement. Nature never works with mathematical precision. Yet the canals have been planned with mathematical foresight. No whim governed the choice of their direction. Invariably they terminate in large well-defined spots, from which they radiate like spokes from the hub of a wheel. If there were one spot, or even two spots, to which a pair of lines converge, we might look on the phenomenon as one of the natural features of the planet. But when more than a dozen lines run with geometrical directness to a single spot, and, when, moreover, the spots themselves are connected by lines and are in no sense isolated, we must assume that an intelligence has been at work.

Aptly enough the spots and lines are distributed in the very regions where we should expect a Martian engineer to place them; in other words just where water is needed. Were it not for their staggering length (fifteen hundred to four thousand miles), we should never see the canals at all. Viewed from a distance of more than thirty-five million miles even so large a city as Chicago or London would be no larger than the head of a pin. What we see is not really a waterway, but, as Dr. Pickering and Dr. Lowell has pointed out, the vegetation that fringes its banks.

Curiously enough, the canals disappear at intervals, only to reappear with their old clearness. On the face of it this would seem in itself an unanswerable refutation to any theory which assumes that the canals are irrigating ditches. It would be absurd for a hypothetical race of Martians to dig canals periodically, only to fill them again. But Dr. Lowell explains the disappearance very simply. What we see is but the seasonal growth of the vegetation along the banks. Time is required for the water of the polar seas to make

Size of Moon to naked eye



The relative visible sizes of the moon and Mars. In the small circle is a photograph of the moon (the size which it appears to the naked eye). In the large circle, is a drawing of Mars exactly the size which it appears through the telescope with a power of 392 diameters—the lowest used.

itself felt; weeks must elapse before sufficiently luxuriant vegetation has sprung into being so that the courses of the canals can be traced each spring and summer. And the peculiar manner in which the canals seem to creep down from the poles at the rate of two and a half miles an hour lends color to the explanation.

The Growth and Death of Vegetation on Mars

This elaborate network of sluices divides the planets into plains of more or less geometrical shape. Blue, green and orange are the colors of these plains—colors that proclaim the character of the areas in question. The blue-green areas are fertile regions fed by the canals; the orange sections are deserts, hopelessly arid. This distinction Professor Lowell draws by reason of the peculiar fluctuations in hue which the blue-green patches undergo with the advent of spring and winter. As autumn approaches they assume a russet tint, which renders it almost impossible to distinguish them from the orange deserts. When the polar snows begin to melt they gradually deepen in shade until they assume the characteristic color of vegetation. Inasmuch as these changes are closely linked with the waxing and waning of the canals, it is evident that the one phenomenon is dependent upon the other.

Dr. Percival Lowell, who erected at Flagstaff, Arizona, the finest private observatory in the world for the special study of the planets. Here for many years he has made those observations of Mars which have made him the foremost authority on that planet in the world

That the spots toward which the canals converge are the objective points of Martian irrigation, is demonstrated by the scientific precision with which the canals have been drawn to meet them. Not a solitary spot is anywhere to be found. Three, four, six, even seventeen canals concentrate their floods on a single spot. In diameter the spots range from seventy-five to one hundred and fifty miles. Like the canals they have been designed with geometrical economy. If there are cities on Mars, it is not unlikely that they are situated in these spots.

Like the canals the spots disappear with the approach of winter; but before they are extinguished the canals have faded away. This is as it should be. Before our time the spots were thought to be lakes and were named accordingly. Professor Lowell regards them as oases studding the Martian deserts. Lakes would never deepen in color; only vegetation can cause the characteristic fluctuations to which the spots are subject.

Are the Canals Real or Merely Illusions?

The amount of ink that has been spilled over the canals and their meaning would fill a hogshead. Many astronomers deny that the canals exist at all and regard them as optical illusions produced by eye-strain. But none of these skeptics has had the opportunity of studying Mars night after night in a clear atmosphere, far from the smoke of cities. Doubting astronomers who have troubled

themselves to journey to Flagstaff or other well-situated observatories are speedily convinced that the canals are objective realities and not illusions. Until 1907 the Flagstaff observatory was the only one devoted to the study of planets and especially equipped and maintained for that purpose. In that year M. Jarry Deloges, at the suggestion of Flammarion, started an investigation of Mars in France and Algeria. The result was an astonishing confirmation of the Flagstaff observations. So similar are the drawings of the Martian disk made nearly seven thousand miles apart that one set might well be taken for a copy of the other. If any evidence were needed to prove that the canals of Mars are real, it is surely found in the *actual photographs* which were first made ten years ago at Flagstaff by Mr. Lampland of Doctor Lowell's staff, and which have been duplicated over again by others since then. Unfortunately the detail in these pictures is so very fine that they cannot be satisfactorily reproduced in the pages of a magazine such as the POPULAR SCIENCE MONTHLY.

It must be admitted that it is not everyone who can see the canals. The man who is a successful observer of faint stars may be quite unable to detect fine planetary detail for structural reasons. Moreover, big instruments, especially in high latitudes, are rather a hindrance than a help in observing Mars.

Granting that Doctor Lowell and his followers are right and that Mars is a living world, what manner of beings are these who have dug canals to water their planet? Unfortunately, no adequate conception of a Martian's physical appearance can be formed, although Edmond Perrier, a French academician, some years ago boldly declared that they must be very tall and very blonde. Romantic guessing is not scientific deduction. Doctor Lowell in one of his earlier works shows that, while we can never hope to draw a picture of a Martian, we can at least deduce something about him because Mars is a small planet.

The bigger the planet on which you live, the harder it is for you to move about. A steam crane would be a welcome assistance in moving your body about on Jupiter. This is due entirely to the enormous gravitational attraction of Jupiter. The bigger the planet the harder are you pulled down to its surface. Mars is only one-ninth as massive as the earth. Hence you would weigh much less on Mars than you do on the earth. A Martian porter could easily carry as much as a terrestrial elephant. A Martian baseball player could bat a ball a mile. Because his planet is not able to pull him down with the attractive force that the earth exerts upon us, the typical Martian has conceivably attained a stature that we would regard as gigantic. Three times as large as a human being, this creature has muscles twenty-seven times as effective. His trunk must be fashioned to enclose lungs capable of breathing the excessively attenuated Martian air in sufficiently large quantities to sustain life. As a canal digger—assuming that he had no machinery—he would be a great success, because he could excavate a canal with the speed and efficiency of a small Panama steam shovel.

1 2 3 4

These drawings of Mars were made under different conditions by observers who knew nothing of each other's activities. And yet the pictures agree in their essential features. Drawing No. 1 was made October 21, 1909, by E. C. Slipher, of Doctor Lowell's staff, at Flagstaff, Arizona; drawing No. 2 was made by Jarry Desloges four thousand miles from Flagstaff on November 13, 1909; drawing No. 3 was made on January 21, 1914, with the Lowell 46-inch reflecting telescope, a magnifying power of 365 being used; drawing No. 4 made by Mr. Slipher about one hour later on the same night with the same instrument and the same magnifying power, shows the same important features.

Is Jupiter Launching a Moon?

The mysterious Great Red Spot on the biggest of planets and what it means to astronomers

IF JUPITER were cut up into one thousand three hundred pieces, each would be larger than the Earth. All the planets together do not weigh half as much as Jupiter. Only the Sun surpasses Jupiter in size.

A year on the planet Jupiter is equal to twelve of our years. Jupiter rotates on his axis in less than half the time of the Earth. But because of the planet's enormous size, the rotation speed is much higher. While the Earth travels 17 miles a minute, Jupiter travels 466 miles a minute. If Jupiter turned on its axis a little faster, it would burst as some flywheels do, when they exceed a safe speed.

Jupiter may be regarded either as a decaying sun or a developing earth. He has not yet had time to cool. He is a great globe of gaseous and molten matter—the most extraordinary planet in the entire solar system.

Because Jupiter is a semi-sun, there is some reason to believe that he possesses inherent light of his own. But astronomers are by no means in accord on this point. Perhaps the clouds, that certainly exist on Jupiter, owe their origin to some other heat than that of the Sun. In other words, Jupiter possesses stores of heat within himself.

Look at Jupiter through a fairly powerful telescope and you will see two broad belts with two or three narrower ones on either side. They lie practically parallel to the planet's equator. Sometimes they are narrow, and when they are very narrow, there is an increase in their number.

Since Jupiter is in a more or less fluid condition, he is surrounded by a dense, cloudy envelope. In all likelihood, the belts are simply rifts in this envelope, exposing the more solid portion of the planet beneath. Not much is known about the belts. While they remain unchanged for months, the fact that they do alter their appearance has led to the assumption that great atmospheric storms take place on Jupiter.

Occasionally Jupiter's belts appear spotted. Just what these spots are, no one knows definitely.

It was in 1878 that the great, mysterious Red Spot of Jupiter, which has puzzled astronomers for many years, was first observed at Brussels by M. Niesten. It was 30,000 miles long one way and over 8,000 miles another. The Earth might figuratively have been dropped into the Red Spot without touching the sides.

For three years, the Great Red Spot was a constant object of study. It completed its circuit about Jupiter in nine hours, fifty-five minutes and thirty-six seconds.

What is the Great Red Spot? A volcano, said some. That is impossible, because it floats freely. It has a strange effect on its surroundings; it has the property of excavating them, as it were. There is a deep bay in which the spot, rather dim now, is located.

In describing the drawing appearing on the opposite page, Mr. Scriven Bolton, the English astronomer who made it says:

"It is propounded that our earth, when once in a plastic condition, rotated on its axis so swiftly that the matter at the equator could not adhere together, and a breach caused a portion to be fractured, which portion gradually separated from the parent planet. So, apparently, in the case of our cousin-planet Jupiter, whose rotational velocity at its surface is as great as ours used to be, there is at present a phenomenon which suggests an epoch in the evolution of moon-making. That puzzling object on the surface, known as the Great Red Spot, is not a fixture of the surface, or we might regard it purely as a volcanic vent emitting hot vapors. Its constituent properties have never been ascertained. . . . It moves round with the planet's axial rotation. This is especially noteworthy from the fact that theory tells us that our moon, in its early stages of evolution, was carried round with the earth's axial motion, all the while just grazing the surface, and that its distance therefrom increased through countless ages, and is increasing. The inference denotes a Jovian moon in embryo."

Is Jupiter Launching a Moon?

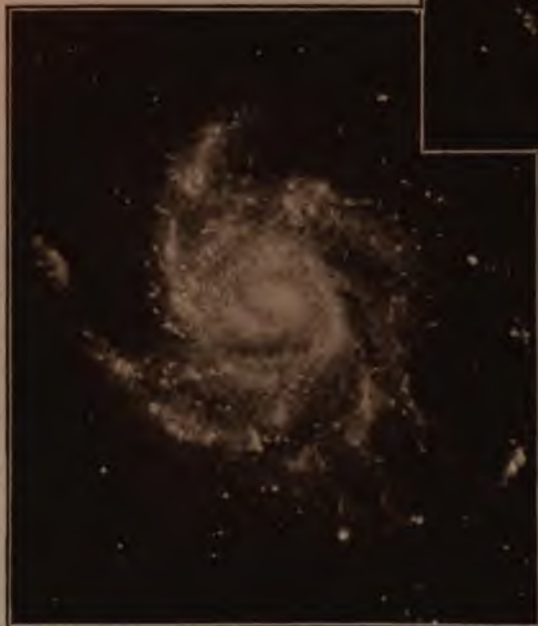
From drawing by Scriven Bolton in Illustrated London News

The Great Red Spot on Jupiter's surface is not a fixture of the surface. It moves around. This is noteworthy from the fact that theory tells us that our moon, in its early stages of evolution, was carried round with the earth's axial motion, all the while just grazing the surface, its distance therefrom increasing through countless ages. The inference denotes a Jovian moon in embryo

Studying the Stars with Mirrors

The biggest reflecting telescope in the world belongs to Canada

By Dr. C. Furness
Professor of Astronomy in Vassar College



Above: Spiral nebula Messier 101, Ursae Majoris, photographed with the two-foot reflector of the Yerkes Observatory. Time of exposure, three hours

Another photograph of the same nebula, taken with the sixty-inch reflector of the Mt. Wilson Solar Observatory. Time of exposure, seven hours, thirty minutes. Comparison shows the greater detail in the lower photograph

IT IS with the reflecting telescope that many of the most brilliant discoveries about stars are made. Its construction, however, is not so generally understood as that of the refracting telescope, the form of instrument which is so often seen in the parks or on the streets of our cities and through which the passerby can get a peep at the Moon for the trifling sum of five or ten cents. By calling attention first to certain facts regarding this more familiar type of telescope, it will be easier to make clear the construction of the reflecting telescope.

The lens at the upper end of a refracting telescope is called the object glass. It collects the rays of light and brings them together at a focus to form an image, which is viewed with a magnifying eyepiece. The largest refracting telescope is the well-known Yerkes instrument. It has an object glass forty inches in diameter.

In a reflecting telescope, the light is collected by reflection from the surface of a concave mirror. If this surface is ground to a parabolic shape, the rays will all come together at a single point to form an image, just as with the refracting telescope; but this point will be situated on the same side of the mirror as the object, and hence the observer who tries to look at a star will find his head in his own line of vision. In order to overcome this difficulty, a second reflection is made to take place, so as to deflect the beam of light and form the image at one side of the tube, where it may easily be examined with an eyepiece. This second reflection is accomplished by means of a plane mirror or "flat" inserted in the upper end of the tube and set at an angle of 45°. This flat will necessarily cut off some of the light falling upon the principal mirror, but since it is not large and since its supports are made as slender as possible, there is no serious loss.

A Mirror Six Feet in Diameter

At first mirrors were made of speculum metal, an alloy of copper and tin, which can be very highly polished. As early as 1842, the famous reflector of Lord Rosse was constructed. It had a mirror six feet in diameter. With this instrument many drawings of nebulae and planets were made. However, it never attained the usefulness which might have been expected, chiefly on

account of its unwieldiness. Mechanical appliances for supporting and moving heavy apparatus had not reached the perfection of the present day, and the six-foot telescope of Lord Rosse could not be moved more than ten degrees either side of the meridian.

On account of these difficulties, interest in the reflector lapsed, except in England, where it has always been a favorite. With the development of photography and its application to astronomy, its usefulness became very apparent. Within the last few decades, therefore, several large reflectors have been built. They are no longer made of speculum metal, but of glass, on the front surface of which a thin film of silver is chemically deposited.

Different Types of Reflectors

In this country there are several large reflectors, some of which are famous for the work which has been done with them. Thus, there is the Crossley three-foot reflector at the Lick Observatory, which was used by Prof. Keeler in photographing nebulae. The results of his labors showed that a very large number of nebulae have the spiral form shown in the accompanying illustrations. The Crossley instrument, however, was not of American origin. It was made in England and presented to Lick by its owner. Its installation was followed by the constructing and mounting of the two-foot reflector of the Yerkes Observatory, under the direction of G. W. Ritchey, who also made the mirror for the great sixty-inch instrument on Mt. Wilson and designed its mounting. A comparison of the two photographs of the same nebula (Messier 101 in Ursa Major), on the preceding page, taken with the two instruments, shows that both of them give beautiful results, but that the larger instrument has a greater wealth of detail.

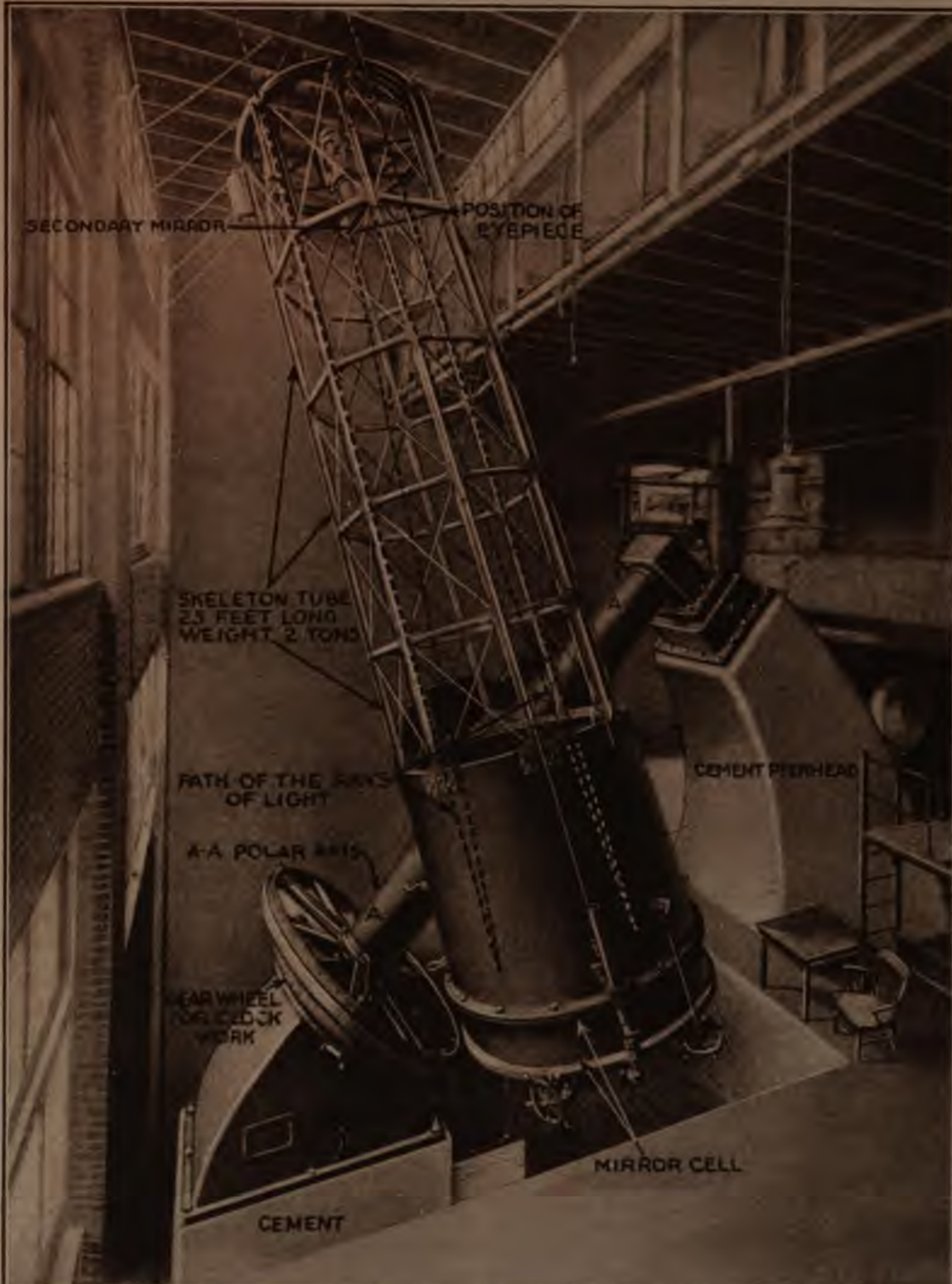
There is a forty-inch reflector at the Lowell Observatory in Flagstaff, Arizona, and two others are in process of construction—a hundred-inch for the Mt. Wilson Solar Observatory and a seventy-two-inch for the Dominion Observatory of Canada which is to be installed at Victoria in British Columbia.

The principles of construction are the same, whatever the size of the instrument, but the great weight of a large reflector makes the engineering problem a difficult one. The building of the seventy-two-inch Canadian instrument may be taken as an illustration of some of the mechanical difficulties to be surmounted, and the accompanying pictures have been selected to show different stages in its progress. One shows the mounting as it was set up in the workshop in Cleveland. The ends of the polar axis AA′ are supported on steel castings which are bolted to the heads of concrete piers. The permanent pier erected at Victoria is shown also. The polar axis must be set parallel to the axis of rotation of the earth. In the latitude of Victoria it makes an angle of more than 48° with the horizon. To the uprights of the framework of the walls are attached horizontal ribs which are for the purpose of supporting the sheet metal walls. It will be noticed that they are in pairs, being fastened both to the inner and the outer edges of the upright beams. The sheathing is attached to both sets, forming thus a double wall, with an intermediate air space of at least six inches. This structure must be made extremely stout in order to bear the enormous weight of the dome. One of the pictures shows the building complete, up to the covering of the dome. This is furnished with a system of shutters which with the double wall permit the interior of the building to maintain an even and moderate temperature. Electric motors are used in moving the telescope and dome. These are controlled by push buttons, located on small keyboards conveniently placed for the observer to use. An important part of the gearing is the clockwork, which carries the telescope with the rotation of the heavens, so that a star can be kept in the field of view as long as is desired. This must be made so that the telescope moves with absolute steadiness.

The optical parts of the instrument are being made by Brashear at Allegheny. The large mirror is twelve inches thick at the edges and will weigh over four thousand pounds.

What Good is a Reflecting Telescope?

Having thus given somewhat in detail the construction of the reflecting telescope, it remains to describe the work which can most satisfactorily be done with it. First, it is used for direct photography, both for recording very faint objects and for getting fine details of brighter objects, such as nebulae. This is perhaps the use which appeals most directly to the general reader. We can also get the photographic images of very faint stars, the twentieth magnitude



Mounting of the seventy-two-inch reflector of the Dominion Observatory of Canada, to be installed at Victoria, British Columbia. The principles of construction are the same whatever the size of the instrument, but the great weight of a large reflector makes the engineering problem a difficult one. The weight of the mirror cell with the mirror is six tons. The polar axis which is bolted to the pierheads, weighs ten tons. The skeleton tube weighs two tons. The dotted lines represent the path of the rays of light. The polar axis must be set parallel to the axis of rotation of the earth. In the latitude of Victoria, it makes an angle of more than forty-eight degrees with the horizon

Above: The iron framework of the walls. Horizontal ribs are attached in pairs both to the outer and inner edges of the upright beams, thus forming a double wall with an intermediate air-space

Above: The building complete, up to the covering of the dome. This is furnished with a system of shutters which with the double wall permit an even temperature to be maintained in the interior of the building

The permanent concrete pier at Victoria. The ends of the polar axis are supported on steel castings which are bolted to the heads of the piers

having already been captured. It is also extremely valuable for spectroscopic work. A long exposure is required even with the great forty-inch Yerkes refractor to obtain the spectrogram of a star of the fourth magnitude. This is much reduced at Mt. Wilson by using the short focus sixty-inch mirror, not only on account of the larger size, but also because the loss of light caused by reflection is *much less than* that suffered by a ray of light in passing through the thick lenses of a large refractor.

Recently, a great deal of attention has been paid to the study of the spectra of nebulae, and some extraordinary results have been obtained. It has been found that some of them show evidences of rotation, a most important fact in its bearing on the evolution of star systems, if it can be established by photography.

Measuring the Light of the Stars

By Joel Stebbins

Professor of Astronomy in the University of Illinois

Prof. Stebbins' remarkable measurements of the heat of stars have attracted the attention of astronomers all over the world. Apart from the value of the results obtained, his work is interesting because it shows that astronomers are making use of modern technical advances, as in the case which he describes, sometimes before they are perfected for commercial purposes.—EDITOR.

ONE of the standard problems of astronomy is the exact determination of the amount of light that comes from each of the stars. Not that the knowledge of the fraction of a candle power of each star is of any interest or importance, but that the measures are valuable for future reference, especially to determine the gradual changes in light caused by the dying out or the brightening of these distant objects. Our own sun being one of a class of stars, the best clue to the life history of the sun may be given by a study of other bodies of the same kind. We also find in the sky numerous extraordinary objects, called short-period variable stars, which change in brightness by fifty per cent or more in the course of a few days, or even hours.

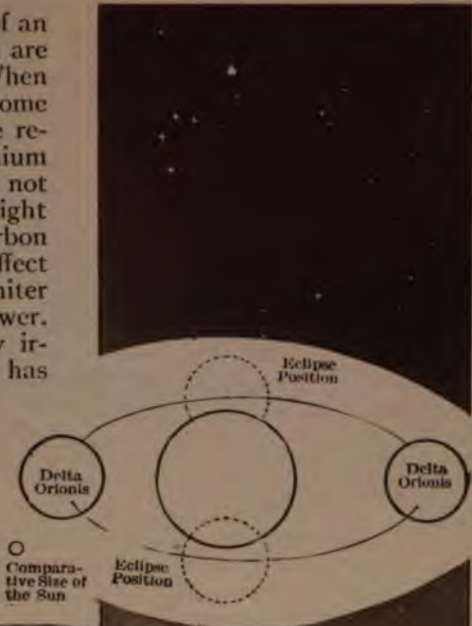
Wanted: A Standard Eye

For general purposes the unaided human eye is one of the best instruments for measuring the light of stars, and most forms of photometer depend ultimately upon the eye for a comparison of two lights. Because of the difference between individuals, however, there is no such thing as a "standard eye," and astronomers have long been waiting for some purely mechanical device which will register light intensities. Let us note that such an instrument is even more in demand for commercial work, especially for testing electric lights. At present the ordinary householder has to take the word of somebody else for the amount of light he is getting from electric lamps. The lighting companies accommodate us with meters telling how much current we use, but we have no exact measure of how much light they are delivering. City authorities contract for a number of lamps of say one thousand candle power each, but who knows after the lamps are installed whether they furnish a thousand or only eight hundred candle power?

We see that there is a real demand for an instrument which, held at a given distance from any lamp, will indicate just how much light is being emitted. Needless to say, many experimenters have attempted to perfect such an instrument, but so far without success. The underlying principle of these devices has been to make use of some substance which changes its properties under the influence of light. One of the most important is the element selenium, a substance in the same chemical group as sulphur. For more than a generation it has been known that the crystalline form of selenium changes its electrical resistance when exposed to light. Other substances exhibit this same property, but none to such a marked degree as selenium. The ordinary arrangement is called a cell or bridge. Two wires are wrapped about an insulator, and on one face the selenium is deposited and then sensitized. The best method of sensitizing is a trade secret, but one standard method is to melt the selenium at four hundred and twenty degrees Fahrenheit, and then let it cool gradually, when it will crystallize and be light-sensitive. There must be a certain amount of mystery in the process, even to the makers themselves, for none of them can furnish cells of a standard resistance, nor even two cells which are precisely alike. On the opposite page is shown an unmounted cell of the usual form. In the dark it has an electrical resistance of about five hundred thousand ohms, but on exposure to strong daylight the resistance drops to about ten thousand ohms, or only one-fiftieth of the original.

The principle of a selenium photometer is, then, to connect a selenium cell with a small battery and to measure the

increase of current, due to light, by means of an ammeter or galvanometer. However, there are several difficulties in this simple process. When selenium is exposed to a strong light, some minutes or even hours are required for the resistance to return to its original value. Selenium is extra sensitive to red light, and so does not give directly a measure of how bright a light would appear to the eye. For instance, a carbon filament lamp with its yellowish light will affect a selenium cell just as much as a much whiter tungsten lamp of double the candle power. Finally and worst of all, selenium is very irregular in its action, and no experimenter has yet solved to his own satisfaction the mysteries of this element.



The Selenium Cell Is Packed in Ice

As applied to the stars, however, many of the ordinary difficulties disappear. Star light is so faint, even at the focus of a large telescope, that the slow recovery of the selenium is not such a drawback; next, since we are usually concerned only with variations of light, it matters little which color is used; and lastly the irregular action may be controlled somewhat by keeping the selenium at a low uniform temperature. Strange as it may seem, when the light of stars is to be measured, a selenium cell at the end of the telescope is surrounded with an ice pack, the ice being renewed every day in sum-

In the circle is shown a selenium cell and ice pack attached to the telescope

The oval diagram above the circle pictures the system of Delta Orionis, showing orbit, eclipse positions, and comparative size of the sun

To the right—Unmounted selenium cell, natural size

mer. Such an arrangement is shown in connection with the telescope of twelve inches aperture at the University of Illinois Observatory. Wires are lead from the telescope to a galvanometer in an adjacent room. Two observers are necessary, one to point the telescope and expose the selenium cell to the stars, while the other reads the galvanometer and records the measures.

With this short description of the device, let us see how results are obtained on the stars. Nearly every one has heard of the wonders of spectrum analysis; how, by studying the light of a star, split up into the different colors, the astronomer has been able to draw certain conclusions about the constitution of the body. For example, it is easily demonstrated that metals, such as iron and calcium, exist as hot vapors above the surface of the sun. It is not so well known, however, that by means of the spectroscope we can study the motions of the stars as well as their chemical constitutions.

It would lead us too far afield to discuss this phase of the subject, but let us state that peculiarities in the spectra of certain stars lead us to conclude that they are attended by large companions or planets which move about them. Such stars are called "spectroscopic binaries," since they are revealed by the spectroscope. The North Star is an object of this class, being in fact a triple system, as there is one body which revolves about the main star in only four days, while a second and more distant companion has a period of a dozen years. In some cases the planes of the orbits of these companions are at such angles that when they pass in front of the main stars there are eclipses as seen from the earth. About one hundred such cases are known, but more are being continually found. The study of these eclipsing binaries is especially important, since they give us the most direct measure of the diameters of the stars. Spectroscopic measures determine the size of the orbit in which the second body moves, while with the photometer is found the duration of the eclipse, which is simply the time necessary for the companion to pass in front of the main star, and hence gives at once the *sum of the* diameters of the two bodies.

The Stars in Orion

Any one who is familiar with a few of the constellations knows Orion, which is in the south in the winter sky. The striking feature of this group consists of three stars in a row, known as the Belt of Orion. The right hand star of the three is Delta Orionis, the Greek letter, Delta, meaning the fourth star in the order of lettering. This object is a spectroscopic binary, the period of the companion being six days. The star was one of the first observed with the selenium photometer, and by comparing it with other stars in the vicinity it was soon found that at intervals of six days there is always a loss of eight per cent of the light, an amount imperceptible to the eye. The eclipse lasts slightly less than one day. After an exhaustive study, the main facts of the system have been brought out, and the appearance of the two bodies as viewed from the direction of the earth is shown to scale in the oval diagram. From simple considerations it is established that the companion is about six tenths the diameter of the main body, and the four small circles show the successive positions of the companion in its orbit, which is not circular but slightly elliptical, and of course viewed at an angle. The dotted circles show the position for eclipses, and we find as expected that when the smaller body is behind the primary there is also an eclipse, but in this case only seven per cent of the light of the system is cut off, as compared with eight per cent when the companion is in front. This demonstrates that the smaller body is seven-eighths as intense for the same surface as the main body, and is hence far from being a dark planet.

The figure shows how close together the bodies are as compared with their diameters, and we also find that we are dealing with a giant system. It is very interesting to note the comparative size of the sun, eight hundred and sixty thousand miles in diameter. The larger star of Delta Orionis has fifteen times and the small star nine times the sun's diameter. The system, brought up and placed beside the sun, would not only appear large, but would be extraordinarily intense in comparison, the surface brill-

f each component exceeding the
least twenty fold, so that the
ht of the system is equal to about
usand suns! Imagine the condi-
the earth if we had such a pair
's to govern us.
pite of their enormous size, the
re not so very massive, exceeding
only about twenty-five times in
and therefore they are much less
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of stars, Delta Orionis, like the
bjects in Orion, is very young,
due course of time will contract
l off and become much more like
n, though of course remaining
assive.
ase here selected illustrates what
revealed by electrical measure-
of light changes which have en-
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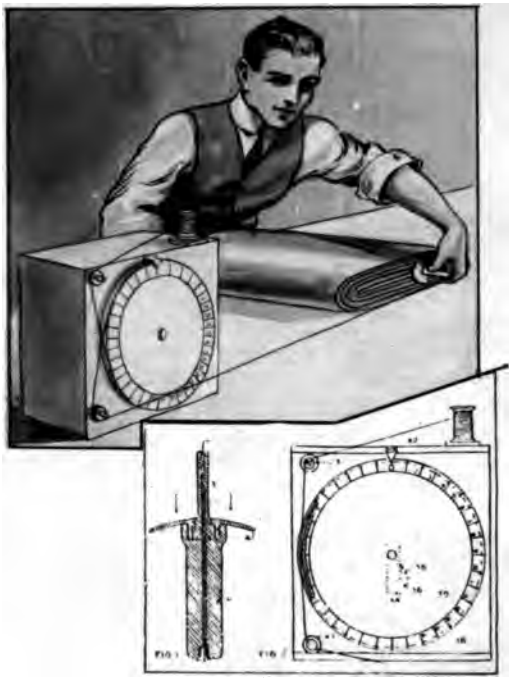
s.

easuring Cloth in the Roll

inconvenience of unwinding a
ll of cloth to measure it has been
d by a clever mechanism de-
y Anthony Fobare. The exact
f any roll of fabric can be ascer-
in a few minutes.
idea consists in passing a thread
the folds of the roll and measur-
thread. For this purpose a tool
in Fig. 1 is used. The thread
through a handle 2, which termi-
n a projection 3 about the size of
knitting-needle. A disk 4 is placed
the handle and the projection.
inserting the projection between
ds of cloth this guard presses
the end of the roll, keeping the



Unwinding a roll of cloth is unnecessary to find its length. A thread can be inserted between the folds and the length of the thread taken

projection a uniform distance from the edge.

The spool is mounted on a box 16 (Fig. 2). The thread is held under tension by passing between two disks 23 held together by a spring. After passing around a large pulley 39 attached to the side of the box, the thread again passes through two tension-plates 43 and then into the handle of the threading-tool.

The circumference of the pulley 39 is just one yard. On the threaded shaft of this pulley is suspended a traveler or rider 34, which moves along the threads as the pulley is rotated. A pointer 38 indicates the number of turns on a scale 36, placed parallel to the shaft. Every turn stands for one yard. The inches are recorded on the face of the pulley, the circumference of which is divided into thirty-six parts. When the measurement is begun the pointer 42 and the rider 34 should both be at zero. The unwinding of the thread, as it is woven into the roll of fabric, is thus recorded in yards and inches.

Here Are a Few Interesting Things to Eat in a

Japanese mackerel steaks smoked and sun-dried to stone-like hardness. When properly prepared they are juicy snacks, so they say. They resemble knife-sharpening bones in this form

Above: A pound of delicately flavored tea packed and compressed by the bare feet of Chinese damsels

Not a toy but an Italian pig's foot stuffed with ham meat. Everything but the tail of cord is eaten. This is but one of many food-freaks that one finds in a visit to sunny Italy

At right: It looks like a football but it's the sun-dried cuttlefish or devil fish of the Greek coast with suckers intact. The shredded part is more tempting than the tentacles

The cuttlefish at the left is of small size. Some are so large that the suckers, when stretched to their full length, can encompass the girth of a half dozen human beings

Below: Sun-dried persimmon fruit of the Orient is the size of goose eggs. Both fruit and shell are eaten after they have been boiled

Above: Sweet butter preserved without a particle of salt inside a gourd-like container made of cheese. The whole remains fresh and edible for years

Above: Lean pork strips sun-preserved without salt in Spain. Deer, buffalo, caribou, bear, goat and tuna meat is preserved in much the same way

Scotch oat-breadstuff in sausage-link form. Mexican corn and black-brown tortillas. Mexico's famed crystalized cactus-pulp is said to be the choicest table delicacy of the west

Sun-dried gizzards of Chinese geese. They are of bone-like hardness but are edible when soaked

Hungry Man's Gastronomic Trip Around the World

Chinese tree-pith breadstuff strips, tamale, and ripened eggs only twenty-five years old

The emergency rations of our soldiers. There are three bread and meat cakes and three pressed chocolate tablets

The pure bean cheese of the Orient is made solely from prepared bean-casein curd

Stringed hazel nuts of the Italians. Below: Sun-dried oysters are a delicacy in China

Smoked pears from central European farmhouses are nutritious when properly stewed

Genuine Turkish caviar in its solid roe form. It is clean to handle and keeps for years

The banana as a dried breadstuff has been used by numerous races for centuries

Cuttlefish preserved in its own ink, the only preserved-in-ink foodstuff known to us

Plum pudding in a bladder container is a great delicacy in southeastern Europe

Chinese-Japanese biscuits made of *wheat and bean flour*

Sun-dried beef of Latin America. Some stretch it for tether ropes

A subterranean passage connecting two distant French trenches. Such is the danger of being shot by enemy sharpshooters while passing from one trench to another, that long communicating tunnels are dug. Sappers start from both ends, and meet in the middle. The illustration shows the first connection between tunnels which have been begun a considerable distance apart, and which are about to be united

Making Air Fit to Breathe

Experimenters are washing it and filtering it in order to free it from dust and bacteria

To test air for bacteria a film of gelatine is exposed for three minutes. It is then placed in an incubator for two days at the temperature of the room

In center above: The rate at which fresh air is supplied to each person is obtained by filling bottles with air and analyzing it for carbon dioxide

No more than fifty thousand particles per cubic inch should be present under the microscope, although some samples have shown twenty million

At left: a gelatine plate after two days of incubation. No more than twelve large colonies of bacteria should result from the air in any room

IT is only recently that health commissions have studied all the conditions that have to be considered in mechanically counteracting drowsiness and the sore throats we get from being shut up all day in our offices, factories, or schools.

Already many important and interesting facts have been brought to light. One of the discoveries which will change the beliefs of many of us is that the carbon dioxide exhaled in our breath is practically harmless; it is only when it amounts to quantities eight to ten times the quantity found in the best air that we begin to be uncomfortable. Nowadays, an engineer will analyze the air of a room for its percentage of carbon dioxide only because this percentage furnishes the best and quickest indication of the number of cubic feet of fresh air which is required for each person.

Important work has been accomplished by the Chicago Commission on Ventilation in determining the exact effects of the humidity, or moisture, of the air upon comfort. They have found that a cold room can be made as agreeable as one that is warm, simply by increasing its humidity.

Dust in the air of a room also lowers the vitality of the people in it, when it is present in 3,000,000 or more particles per cubic inch.

We now understand why the previous systems of ventilation—of which some are still in use—were not satisfactory. In these systems only the supply of air and its temperature were regulated. They lacked the means to moisten and dry the air and to cleanse it sufficiently of dust.

Fun With Pictures of Your Friends

If you would like to have a little fun with your friends, try enlarging a group negative or single figure after this fashion: First place the negative in the enlarging frame in the usual manner. After the desired size of print has been decided upon and focus made for size, tip the frame or sliding-board (on which sensitized paper is placed) gradually backward, until the persons or scenes assume fantastic shapes. The best angle of the board will probably be around forty-five degrees, although some negatives require a greater angle to change them.

A print from the negative of your thin friend will reveal him as a very stout person, but without losing the facial likeness in the process. By tipping the board backward, everything seen in the negative, is lengthened, so that the fat man becomes a tall, thin person and a stubby tower becomes a factory chimney.

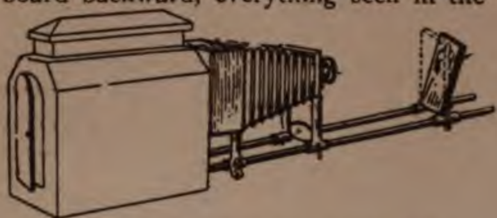


Diagram showing the arrangement of the sliding-board for making trick pictures

The length of exposure needed will be found to be about the same as when the board is in the normal position. Duration of exposure depends on the size of the stop used. It is not necessary to own an expensive enlarging outfit, since the trick can be done on anything from a "Brownie" to the professional apparatus. Try it on your friends.

Tip your sliding-board at forty-five degrees sidewise and you make the whole world rotund and happy

If the tilt of the board is the length of the picture, thinness becomes an attribute of all

A Metal-Vapor Light That Is White

A NEW vapor lamp employing the vapor from metals has been patented by a German scientist. Zinc chloride and zinc bromide have been used and give the best results at atmospheric pressure. As in the mercury-vapor arc, the inclusion of air or other foreign gases in the tube is prejudicial. On the other hand, an arc in an atmosphere of aluminium chloride or titanium chloride is more stable, and an admixture of nitrogen is harmless. Oxygen, however, must be excluded. It is stated that the color of the light is white, and that the efficiency is in the neighborhood of that of the mercury-vapor lamp.

The fact that the light is white will greatly add to the importance of the lamp, since there are many uses which demand such illumination.

If We Had Eyes Like Microscopes

By Edward F. Bigelow

CERTAIN writers, chiefly Dean Swift and his followers, have taken pains to impress upon their readers the fact that if they had microscopical eyes, all beauty would disappear. The most delicate skin viewed by such eyes would be rough and repulsive; the whole world would be filled with disagreeable sights.

On the other hand many enthusiastic microscopists teach and believe that beauty is increased by the microscope. According to them, if we had microscopical eyes, a world of beauty unimagined would be open to us, and every object would appear to be perfect and beautiful.

The disputed facts are like those in many other cases: each is right from his own point of view. The microscope does detract from the beauty of some things, and reveals new beauty in others. The appearance of nature to a microscopical eye would not be much different from its appearance to what we now consider the normal eye. At present, some things are unpleasant to look at; yet we are living in a world of beauty—everywhere.

The delicate mosquito's wing revealed through microscopical eyes

In some things nature will not bear close scrutiny. In others, she has hidden beauty that is revealed only by the microscope. Among the most beautiful of finely constructed objects, few are perhaps more attractive than a mosquito's wing. Its tiny scales become more and more beautiful and wonderful as we increase our magnifying power.

The utilitarian reader may ask, "Of what use are such things?" They are good to be themselves. It is better to take the world as it is and to study it, than so often to ask, "Why?" It would be difficult to explain the reason for the existence of many of nature's common objects. In regard to the mosquito's wing with its feathers, we can only surmise that these scales may be useful in preventing the air from slipping off too easily; the slight roughness may give the wing a firmer hold on the air. For a similar purpose a bird's wing is feathered, and this reason is brought into more conspicuous prominence by the fact that a fish's fin is free from scales.

Here, aside from its reason for existing, the microscopist finds a realm for delightful investigation; the further afield he goes with his high-power objective, the greater the scope of inquiry. It is impossible in a photomicrograph such as the accompanying, although it is a remarkably good picture, to show the minute details, because the structure is so hyaline or transparent, that it is not easily photographed. Under high powers the wing becomes even more hyaline.

If the reader will think of a room full of smoke, he will understand this. If a small quantity of this smoke-laden atmosphere be taken in a phial, the blueness will become invisible, or at least inconspicuous. When viewing a mosquito's wing it is difficult, under high magnification, to have enough material to make much impression upon the plate; but in a compound microscope the light may be so adjusted that, while the wing may appear almost perfectly transparent, there will yet be sufficient material to make a distinct image in the eye. There seems to be nothing too minute for the microscope to reveal.

Band Concerts from an Electric Light Bulb

By George F. Worts

MUSIC that ranges from the piercing wail of a taut violin string to the grumbling bass of a monster horn has been added to the remarkable achievemnts of an electrical instrument so small and so insignificant in appearance that it could be passed by scores of times without arousing so much as a lingering glance.

Despite its innocent appearance, however, its technical name is more than formidable. Scientists know it as the "oscillating vacuum tube," although this name has been changed and shortened to a simple compound word, "audion." "Audion" is derived from audio, to hear, and ion, the tiniest' division of electricity; in other words, to make audible the action of ions. This, in a word, is exactly what the oscillating vacuum tube accomplishes.

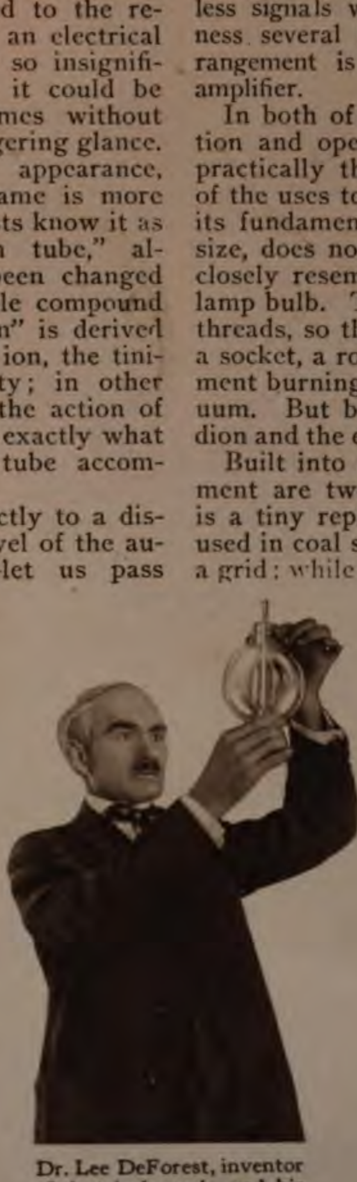
Before proceeding directly to a discussion of the latest marvel of the audion,—electrical music—let us pass hurriedly over some of the achievements that have preceded it, which, in a round-about way, have led to the discovery.

Amateur and professional wireless operators know the audion well, although numbers of them are not aware that it has other uses than the reception of radio signals.

Connected with the proper wireless instruments, the audion will receive and strengthen the weak signals of a distant radio station to a degree several times as loud as any other detector. But its ability in this direction does not stop there. If several of the tubes are connected in the correct way and adjusted with great care, the wireless signals will be increased in loudness several hundred times. This arrangement is known as the Audion amplifier.

In both of these uses, the construction and operation of the audion are practically the same. In fact, for all of the uses to which the audion is put, its fundamental structure, apart from size, does not vary. In appearance it closely resembles an ordinary electric lamp bulb. There is a brass base with threads, so that it can be screwed into a socket, a round glass bulb and a filament burning brightly in a partial vacuum. But beyond this point, the audion and the electric light are strangers.

Built into the bulb close to the filament are two metal electrodes. One is a tiny replica of the grids that are used in coal stoves .... and it is called a grid; while the other is a small plate.



Dr. Lee DeForest, inventor of electrical music, and his audion bulb

The grid and the plate are connected to the other apparatus in such a way that a perfect balance, electrically speaking, is maintained between them. When an outer influence, such as an incoming wireless wave, is brought into the bulb, this balance is disturbed, and in a strengthened form, the disturbance is heard in the telephone head receivers as the dots and dashes of the wireless code.

Strange to say, this same balancing principle is made use of in another application directly opposite in na-

ture to the foregoing, when the vacuum tube is employed as a wireless telephone. Hundreds of the bulbs are connected to a powerful battery or dynamo. The voice spoken into a telephone transmitter connected in the circuit so disturbs the electrical balance of the bulbs that powerful waves are created. The most striking example of this application was the recent feat of telephoning wirelessly from Washington to Hawaii.

Another use of the audion is in relaying the current that carries the voice over long distance telephone lines.

The other applications of the audion are of a laboratory nature. One of these applications is transforming electricity. By throwing a small lever, the outgoing current can be varied from fifty to more than a million vibrations a second.

By the combination of some of the foregoing properties of the vacuum bulb, the uncanny but delightful result, electrical music, is attained. The idea of converting the silently flowing electric current into strains of the most bewitching music is not entirely new. Many readers will recall the telharmonium, which was built at great cost several years ago and with which electrical concerts in the home were prophesied. But the telharmonium required dynamos of such variety and size that it was eventually given up because of the prohibitive cost. Music from electricity—or music from light, to be exact—goes back many years before the telharmonium. Legendary Egyptian history, three thousand years old, tells us that the rays of the descending sun, would strike weird music from the face of the statue of Memnon.

Incredible as this tale may seem to

In appearance the audion closely resembles an ordinary electric lamp bulb. Built into the bulb close to the filament are two metal electrodes which are connected in such a way that a perfect electrical balance is maintained between them. When the wireless wave disturbs this balance, the disturbance is heard in the telephone receivers

us now, the present day accomplishment of electrical music is hardly less astonishing. To an ordinary audience, the fact of most striking importance would be the quality of the music. It is quite possible to imitate the mellowest tones of a Stradivarius violin, but more interesting still, it is possible to create music of a tone and timbre that no one in this world has ever heard before. No less strange than the quality of the music is the means by which it is obtained. The variations produced in an electrical circuit by inserting a lead pencil line drawn on paper will cover not only the complete octave, but will include the most infinite shadings in tone.

Dr. Lee DeForest, the discoverer of this type of electrical music, claims that with an arrangement of four or five bulbs and suitable adjusting apparatus and keys similar to those of a piano keyboard, he can easily obtain notes ranging in pitch through as many octaves as are desired and a tone quality identical with that of all musical instruments now in use as well as qualities never before produced.

The volume of sound depends upon the adjustment, the number of batteries that are used and the size and number of electric horns which project the sound. The horns can be distributed in various parts of the room or grouped together.

The basic principle involved in creating music by a vacuum bulb, Dr. DeForest does not attempt to explain. Nor does anyone else. Perhaps it is due to the unbalancing action caused by interference with the flow of the current. In this case, the tiny particles of electricity loosened, bombard the grid and the iron plate in musical rhythm. At all events, the action is probably highly complicated, and it may involve some new principle of electricity that we have not yet learned.

A Walking Leg Bath

AN interesting and unusual way of using water as a curative measure is represented by the "walking leg bath" evolved by a Battle Creek sanitarium and included in its list of helpful apparatus.

Tingling streams of cold water bring the blood rushing to impoverished muscles as a patient walks through this leg bath

The walking leg bath is a simply constructed frame, lined with a number of woven wire springs and equipped with two water pipes, perforated at inch spaces to permit a horizontal shower. This strikes the legs at the moment when the muscles are in action and most open to benefit.

The patient is told to walk through the bath briskly, and by the continued performance of that act alone he improves his condition, the wire springs against which he must brush in passing, insuring a brisker circulation. The needle-like streams of water—at varying temperatures—forced against his legs by air pressure heighten the effect. It is one of the most exhiliarating of the modern "cures."

The walking leg bath is recommended in certain forms of rheumatism, varicose veins and other maladies affecting the lower extremities.

The King of New York's Lighting Spectacles

FRAMED by the masonry portals of the Municipal Building the Woolworth tower by night represents one of the greatest artistic achievements in this age of electrical wonders. For more than a year now the thirty-storied tower has burst out into the night as a giant shaft crowned with a scintillating jewel. When that part of the building below the thirtieth floor is dark the tower takes on the appearance of a huge crystal hung by invisible wires from the skies. When the switches are pressed into sockets illuminating the structure more current is employed than is necessary to light the streets of a city of thirty thousand inhabitants. Six hundred automobile lamps are contained in the electrical installation.

The lights are so arranged that they flood every inch of the structure. An ingenious system of screening prevents the rays from shooting directly downward or upward, thus revealing the source of light. Anyone viewing the spectacle from below is vexed to find where the light comes from.

Photo by Levick

The Woolworth tower is the king of New York's skyline at night. Its crown is a great scintillating jewel

Origin of Gas Jets Traced to Woman's Thimble

A WOMAN'S thimble is said to have been the means of suggesting the first gas burner. William Murdock, the inventor, first burned the gas simply as a flame from the end of a pipe. One day in an emergency he wished to stop the illumination. Hurriedly looking around for something, Murdock seized his wife's thimble and thrust it over the light, which was immediately extinguished. There was a strong odor of gas, however, and the experimenter applied a light to the thimble, discovering that it was full of holes, through which tiny jets of flame appeared. The importance of the result was that the illumination from those two or three tiny jets was much brighter than had been given by the great flare from the end of the pipe. Acting on the principle which this chance discovery revealed, he constructed what was known as the Cockspur burner.

Telephoning from a Moving Train

BY means of the moving train telephone invented by A. A. Macfarlane, communication between fast moving trains may now be possible. Communication has actually been held between the experimental station and New York city. In this experiment the rails of the track were used for part of the conducting medium.

On a sidetrack near the little town of Bridesburg, Pa., experimental work has been carried on with a steel freight car. At one end of the section of track used, a two-volt battery is connected; at the other end a signaling and telephoning device is located between the tracks. The equipment consisted of a "puzzle" box and copper shoes that pick up currents from the rails. The nature and contents of this box are not being given out at present on account of some patents pending. The inventor states that what the device accomplishes is made possible, however, by his furnishing to the current a path of least resistance. Without this device, current would follow the track, run through the wheels and axles and jump to the other rail and produce a short circuit. The current simply avoids its natural outlet, follows the track until it reaches the box and shoes, where it is picked up and taken aboard the train.

Telephoning between moving trains is but a part of the importance of the invention. The real object is to produce a signaling system that will bring the danger and clear signals into the cab of the engineer. An automatic brake has also been added and tested on an engine. The device will light colored lights in the cab of the engine, as well as furnish an automatically operated block for approaching trains. Into each block current will be furnished by batteries along the track. When a train is in this block it will short circuit the current, so that a train approaching will be automatically stopped by the brake device operated in connection with the system.

In the telephone system it will be necessary to have batteries along the track, and by the use of the shoes and box device with which the train will be equipped current will be furnished it. Then the telephone can be operated, and connection can be had through the main wires along the track, the current being carried out at the ends of the blocks. By this system, the inventor claims a moving train can be in communication with any telephone in the country.

The two rails of a track are used as wires for telephoning to moving trains. In the circle is shown the shoe by which the connection is made from rail to locomotive

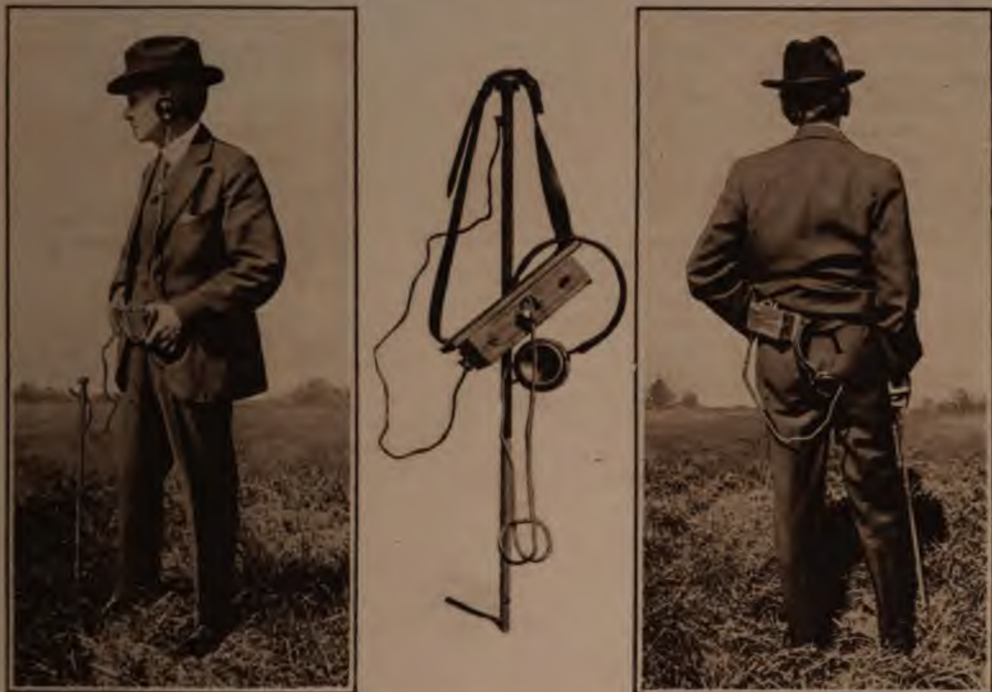
Lengthens Life of Rubber Gloves

A NEW process for vulcanizing seamless rubber gloves has been brought out by which the life of the gloves is said to be considerably lengthened. Instead of vulcanizing the glove on the dipping frame after the several coatings have been applied, each consecutive layer is vulcanized as the glove structure progresses

Another Pocket Wireless

SINCE the beginning of the European war, many compact, light wireless receivers have been proposed for military use. It is not at all difficult to build a tiny apparatus, which may be carried about, concealed in one's clothing, yet which will receive "radio" messages from nearby powerful wireless stations. In this way, if a good electrical connection to earth can be made by way of a metal staff forced into damp earth, signals may be heard several miles. If, in addition, considering the liability of electric shock from the instruments, to carry enough batteries for sending messages even a mile or two would be more than any ordinary man would care to attempt. A small sender can be built, however, strong enough to send signals a few hundred feet, yet compact and light enough for a person to carry.

Dr. H. Barringer Cox, of Bedford Hills, New York, has devised and built an interesting set of such portable appa-



With his pocket wireless aparatus attached to his body, Dr. Cox, the inventor, becomes a veritable radio station

an umbrella is used to hide an "antenna" wire for absorbing the energy of the passing wireless waves, still greater distances can be covered. All of this has been done many times, and, in fact, small instruments for the secret reception of wireless messages have been on sale in various European cities for several years.

To build a similarly portable wireless sender is a very much more difficult thing, however, because considerable power is necessary if messages are to be transmitted more than a few yards. Without

ratus. The photographs herewith show the receiver and the way in which it can be hidden from view by strapping it underneath the operator's coat. The heavy staff is used to connect with the earth; a wire run inside the trouser leg and connecting to a heel-plate can be made use of when the stick proves inconvenient. Dr. Cox's sender and receiver may both be worn on a single belt; and two men thus doubly equipped would be able to communicate secretly.

Demonstrations have been followed

with considerable interest. In one test a small sender consisting of a vibrator, operated by five dry cells, was connected to an automatic Morse transmitter and left to radiate its messages throughout the neighborhood. The receiver was then strapped on, and it was found that the signals could be heard quite distinctly some distance from the sender. When the transmitter was connected to a water-pipe as well as a bare vertical "aerial' wire, greater space could be covered. Similarly, when the receiver was lifted higher from the ground, the received signals were intensified.

Dr. Cox uses in his apparatus a specially built transmitter, the construction and operation of which he will not discuss. Aside from this, however, the entire set of instruments is believed to be quite similar to those developed by others. Some further improvements are being made, and it is thought that this latest "walking wireless" may find use in the present great war.

Electricity Sifts Sand

The old-time sand sifters of our youth have been relegated to the scrap heap. Today in the modern foundry, and other places where screening of sand is a necessity, electrically operated riddles, or sieves, are installed. These sifters of sand work without interruption and do the work of ten men.

This electric sand sifter does the work of ten men

A crude water wheel which makes the river pump its own water to irrigate a California farm

The electric riddle requires but one-sixteenth horse power to drive it and the apparatus can be run on a trolley along a line of twenty moulders, supplying perfectly clean sand as fast as it is poured into its receiving pan.

A River Which Pumps Its Water

In a number of sections of northern California there are vast tracts of land which are watered only by irrigation and where the government has not yet carried out any reclamation projects, even on the smallest scale. The settlers and ranchers have improvised irrigation facilities of their own. These appliances, though crude and original, are none the less effective. Some of the best are used by the ranchers of the narrow winding valley of Klamath river.

Numbers of large irrigating wheels, operated by the river current, are in operation here. These are about eighty feet in diameter, built of wood and strongly braced to withstand the current. At short intervals are placed "flood boards," on cross-paddles, which, when immersed in the water, cause the wheel to revolve as the current strikes them. Attached to the outer rim, on each side, at short distances, are large box-like metal buckets, which are successively filled, hoisted and emptied into wooden flumes. Thence the water flows in side flumes into deep ditches dug along the high banks of the river. Many of these ditches are miles in length, and the water is distributed for leagues.

Exterminating Mosquitoes

NEXT to draining, the best way to abolish mosquito breeding places is to treat the water so as to kill the mosquito larvae and while many substances have been tried for this purpose, nothing has given such good results as petroleum, according to experts of the United States Department of Agriculture. Common kerosene of low grade is most satisfactory as regards efficiency and price.

It has been found that spraying with a portable pump is the best way to use the oil. Small ponds, however, can be sprinkled out of an ordinary watering-pot with a rose nozzle, or for that matter pouring it out of a dipper or cup will be satisfactory. In larger ponds pumps with a straight nozzle may be used. A straight stream will sink and then rise and the oil will spread until the whole surface of the water can be covered without waste.

In choosing the grade of oil to be used two factors must be considered; it should spread rapidly and should not evaporate too quickly. Heavier grades of oil will be apt to gather in spots and the coating will be necessarily thick. It has been found that one ounce of kerosene is sufficient to cover fifteen square feet of surface, and in the absence of wind, such a film will remain persistent for ten days. Even after the iridescent scum apparently disappears there is still an odor of kerosene about the water. A mixture of crude oil and kerosene has been found to be effective in killing mosquito larvae. It has one very decided advantage over pure kerosene which is that it does not evaporate so quickly.

Special attention should be paid to little pockets of water that form around the edges of ponds, for it is in such places where the water is not disturbed by wind or otherwise that the larvae breed in greatest numbers. Larvae do not breed in open stretches of water where the surface is rippled by the wind.

In the fight against the mosquito in Panama, the government experts found that a larvicide composed of carbolic acid, rosin and caustic soda was very effective and thousands of gallons of it were used. Crude oil was employed in streams having a fair velocity.

Covering the Surfaces of Ponds and Other Breeding Places with Petroleum, According to Experts of the Department of Agriculture, Is the Best Move Against Mosquito Larvae. The Illustration Shows a Pond Being Sprinkled with Petroleum from a Portable Pump

An interesting exposition of the relationship between the human skull and its flesh. Scientists have made such a careful and exacting study of this relationship that they can reconstruct a face from almost any skull.

Reconstructing Facial Features from the Skull

WHEN Shakespeare, in his impressive and uncanny Gravedigger Scene, causes Hamlet to recognize one of the skulls as having belonged to Yorick, the dead jester, he may have merely been providing his audience with a fantastic, over-imaginative thriller. But in the last century the scientist anatomist has undertaken the almost impossible task of demonstrating that all human skulls possess sufficient points of difference to enable him to reconstruct, by means of portraits and death-masks, an actual likeness of the face of the individual who during his lifetime proudly bore the skull on his shoulders. To the layman, in fact, all human skeletons and skulls appear to be hopelessly similar; indeed, it is only in real life that we can distinguish, thanks to differences in facial characteristics, one person from another. But science has succeeded in reconstructing the human face with nothing but the skull and a portrait or a death-mask to furnish the clues.

The inspiration for this fascinating work of reconstructing the human face occurred as the result of a famous controversy over the skull of Schiller, the German poet. Upon his death, his body had been immured with twenty-two others in a vault in the cemetery at Weimar, Saxony. When, in 1826, this vault had to be emptied, the coffins were so completely decayed that Schiller's could not be recognized from the others. Accordingly, a comparison was then made between the twenty-three skulls and the only known death-mask of Schiller; and in the unanimous opinion of a large body of so-called experts, the largest skull was decided to be Schiller's.

Upon the subsequent discovery, however, of a second death-mask at Weimar, the German anatomist, Welcker, compared both masks with the supposed skull of Schiller, and made the startling announcement that there was no resemblance between it and either mask; consequently it could not be the skull of Schiller. His views, of course, were not widely accepted, and caused a long and fruitless controversy between 1884 and 1887. Twenty-five years later, Prof. von Froriep found another skull in the vault, which he maintains is the genuine Schiller skull. He made profile drawings of this skull and of the mask, and fitted them together. He obtained the exact thickness of the fleshy parts of the face from a large number of measurements of suitable corpses; and his conclusions are now accepted as valid and beyond dispute.

By a similar method, the genuineness and authenticity of the skulls of the artist Raphael, and of the musicians

A phantom view of the skull of the prehistoric woman of Auvernier and the probable flesh covering which it had. At the right is the modeled face of the woman.

Haydn and Bach, have been successfully and completely settled.

When no portrait or death-mask of a person exists, the face is reconstructed by a different method. Such was the problem presented by a well-preserved skull found in a prehistoric pile dwelling in 1878 at Auvernier, near the Neuenberg Lake. From its appearance, it was evidently that of a woman about thirty years old, who had lived in the bronze or stone age, 7000 or 8000 years ago. In order to reconstruct a likeness of this prehistoric relic of the white race, it was necessary to ascertain the normal thickness of the flesh in various parts of the face. This was determined by a series of very careful measurements of the faces of eight female corpses. A very fine needle, with graduations of 1/100th of an inch, was used in these measurements. After many tiny plaster pyramids were erected all over the skull to correspond with the data, they were connected with a layer of clay, the surface of which was flush with their tops. The result was a rough clay reconstruction of the face, which was completed by an artist named Buechly, whose skill and imagination supplied the hair and neck to complete the famous lifelike bust of the Woman of Auvernier.

A Mobile Motion Picture Studio

A complete travelling power plant, installed on a high-powered motor car, and able to furnish light for outdoor motion picture photography, is the latest addition to the equipment of the Lubin Company. This mobile power plant is equipped with a powerful generator, connected with a switchboard to which many different circuits may be run for the successful illumination of an outdoor scene. A thirteen-inch navy searchlight, with a capacity of 4,500,000 candlepower, mounted upon the car, makes one think of the pictures of the great searchlight cars with the armies in Europe. The entire plant and automobile weighs approximately eight thousand pounds. Compactness and simplicity of the plant was the principal aim in designing the unit. It is said that remarkably successful night effects have been produced with the aid of the machine.

During a recent aerial attack upon Venice by the Austrians, a high explosive bomb fell upon the Church of the Scalzi and completely ruined the wonderful ceiling decoration which was renowned throughout the entire world. According to an art critic who examined the church, "Nothing but fragments of dust remain, and the loss is irreparable"

Telegraphing with the Telephone

THE man at the telephone is telegraphing. He is Paul P. Banholzer Philadelphia, connected with the steam engineering and electrical department of the Navy. He has increased the efficiency of the telephone by devising a telegraph-transmitter which can be attached to any telephone standard. The connection between the two instruments is purely mechanical and not electrical. The device does not require an additional electric circuit. Its advantage lies chiefly in the fact that the Morse signals sent by this instrument carry farther over a long distance telephone line than the voice and that the sounds produced are definite and unmistakable even to an inexperienced person.

A telegraph-key attached to a telephone, which places the whole vast telephone system of the country at the disposal of the telegrapher

The instrument is especially useful in telephone train-dispatching. If the telephone conversation is not clearly understood it can be verified, or supplemented by the telephone-telegraph instrument.

The doctor did not care to carry a medicine case, so he filled a hollow cane with pills instead

The telegraph-key is mounted very much like any other telegraph-key, except that it is pivoted at its extreme end; the sound that it produces is sharper than that of the ordinary telegraph-key and is conducted to the telephone through the metal base and through clamps which encircle the telephone standard and fasten the instrument in place.

The apparatus is being tested out at the Philadelphia Navy Yard with wireless. It is claimed that if conversation can be transmitted by wireless telephoning, telegraphing by wireless telephone with this instrument, can be conducted by any "wire" operator, and that it will be possible to introduce wireless on all railroads. When telegraph wires are down, this device can be used on the telephone circuit in conduits underground.

Cane Holds Doctor's Medicines

AN eccentric physician, who did not like to be seen carrying a medicine-case, devised a hollow hard-rubber walking-stick with a sliding metal holder for the bottles of tablets and powders and other first-aids. This metal holder is a half-tube, slightly crimped at the edges, so as to grip the bottles tightly enough to prevent them from falling out when the tube is pulled out of the cane. To all appearances the cane is just like other walking-sticks, but when the old physician removes the handle, by unscrewing it from the straight part of the cane, a sort of button is revealed, which serves as a means of grasping and pulling out the tube with its drugs.

The Photographer in His Aeroplane Can Point the Pistol-Camera with Great Accuracy at the Object To Be Photographed. The Two Focusing Frames Take the Place of Sights on a Revolver. The Trigger Operates the Shutter

"Shooting" a Photograph with a Pistol-Camera

OF the number of aerial cameras which have been designed to meet the requirements of modern reconnaissance work in the present war perhaps the most novel and interestirg apparatus is a pistol-camera used by German airmen which is now in the possession of the French. Jean Navarre, a daring young French flier who brought down his fourteenth German aeroplane early in April, found the camera in an Aviatik which he forced to descend within the French lines in the Soissons neighborhood.

The camera was intact and in working order. In fact, there was reason to believe that it had been used the same day it fell into the hands of the French, although no plates were exposed. Several were in position, however, ready to be exposed. The pistol-camera has the shape of an enormous pistol, and looks unwieldy because of its large size and grotesque shape. It has a pistol grip and trigger similar to that on all makes of revolvers.

The shutter of the camera is operated by pulling the trigger. The photographer points the apparatus with dead accuracy at the object to be photographed and with a slight movement of his finger takes the picture. The two focusing frames, which are nothing more than common gun-sights in disguise, enable the photographer to level his camera with absolute certainty.

The length of the camera box is a little under two feet, and its weight about thirteen pounds. The French have tested the photographic capabilities of the apparatus by experimenting with it in their own aeroplanes. Excellent results were produced. In some cases clear and distinct photographs of military value were taken at altitudes of upwards of six thousand feet. This camera is the only one of its kind to fall in the hands of the French.

Why a Featherduster Is Like a Fly

ANYBODY can see a feather duster in the hands of the housekeeper, but it takes a microscopist to discover that the fly uses a similar duster in the characteristic and amusing performance known to children as "fiddling." From its own viewpoint the house-fly is neat and cleanly, but it cares not where it scatters its dust, nor how much it inconveniences and menaces human beings. The fly dusts its body with praiseworthy industry and continuity, passing one leg over the other with a peculiar rolling motion, using each like a featherduster, and the leg being dusted as another duster.

Under the microscope, the legs, not only of the house-fly but of others related to it, are seen to be covered with hairs and bristles, which under low power, give the entire leg a feathery appearance. In some flies even the terminal claws are hairy. The fly is evidently annoyed by the dust, and much of its spare time seems to be devoted to the fiddling process. A microscopist who wants to prepare a fly for microscopical study usually allows it to develop under a bell glass, or in some other condition in which the dust cannot soil the specimen. The accompanying illustration of a fly's fiddling legs show, even under the highest power of the microscope, not the slightest particle of dust, because the fly was prepared immediately after such transformation. The purpose of the picture is to display the feathery legs in their fiddling position, free from dust. The freedom from dust is, in this instance, due to the skill and ingenuity of the microscopist, not to the diligence of the fly.

With these featherduster-like legs, the fly spends much of his time freeing himself from particles of dust

The moral of the picture: A feather duster in the hands of a diligent housemaid can spread more disease germs than a hundred flies with their microscopic feather dusters, and the mechanism is the same. Campaigns against the fly should include the duster-wielding housewife. Placards should be exhibited with pictures of a fly and a housewife and with this legend: "These two animals spread disease with their featherdusters"

Paraffin Protects the Labels of Chemical Bottles

IF the amateur chemist will paint a thin coating of paraffin over the labels of his reagent bottles with a fine brush he will be saved much time and bother in replacing labels. The paraffin will prevent any drops of reagent from attacking and badly discoloring the labels. Most reagents do not act on paraffin. The paraffin coating should extend about one-quarter of an inch beyond the edges of the label.

In making a long cast the steel fishing rod was thrown against high-tension wires and the fisherman was killed almost on the instant

A Warning to Fishermen

WHILE fishing in a small Pennsylvania stream the Rev. W. P. Perry was killed almost instantly when the steel rod he was holding became entangled in high-tension transmission wires over his head. He was wading in the stream at the time and whipping the water in the usual way. With no thought of the live wires he made a cast with the line and there was a blinding flash. The current of twenty thousand volts leaped down the rod, coursed through his body, and killed him before he could make an outcry.

This is said to be the first instance on record of the death of a man under such circumstances. During severe winter storms it is not infrequent to hear of electrocutions, due to fallen live wires hidden in débris.

Expending Four Tons of Energy in Playing the 'Cello

A SIMPLE air played on the violoncello calls for a total expenditure of energy equal to two and three quarter pounds per note or more than four tons of energy for the single selection. This statement is vouched for by Professor Poffenberger, of Columbia University, who made some experiments in his laboratory with the aid of the famous Dutch 'cellist Michael Penha—experiments made to determine the amount of sheer physical strength required to play the violoncello in the style of a great artist.

A special apparatus is necessary to conduct the tests. Against the surface of a revolving carbon cylinder is suspended a chalked point which is actuated by a slender wire attached to the musician's finger. At each pressure the tension vibrates along the communicating connection and records the energy expended.

When Michael Penha played a simple Bach aria this instrument registered an expenditure of more than four tons of energy

"Roly-Poly" Square, Lisbon, Portugal. So-called because of the peculiar undulating pattern of its mosaic pavement. The square contains two bronze fountains and a lofty pillar surmounted by a statue of Pedro IV

The rack and pinion railway of Funchal, Madeira, connects Funchal with the Monte, a village on the mountain above. Visitors descending from the Monte generally use a curious running sledge. Two attendants are provided, wearing rubber-soled shoes. They run behind and check a too-rapid descent by holding on the guide ropes

ODD SCENES IN ODD CORNERS OF THE WORLD

Why Is the Sky Blue?

Sunlight, which we call white, is composed of light rays of different colors—red, orange, yellow, green, blue, indigo and violet. It can be broken up into its constituent colors in various ways. If it passes through a transparent prism (like the crystals that hang from a chandelier) or if it falls on a surface which has almost invisibly minute irregularities (like mother-of-pearl or the wing of a butterfly) we see the rays into which sunlight has been separated. These phenomena are observed when light is not absorbed.

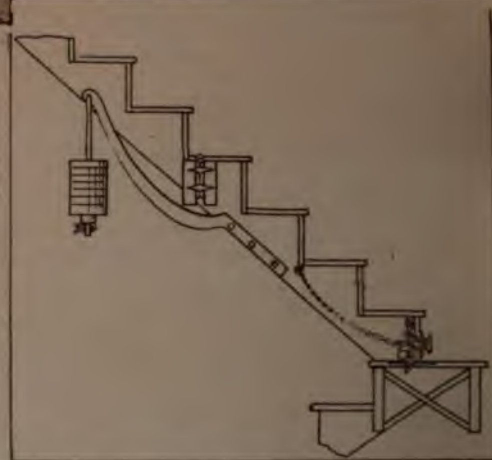
Hold a piece of red glass in front of a flame and we see only red. Rays of all other colors have been absorbed. The natural colors of the objects we see about us, leaves, flowers, books and chairs, depend upon absorption. A green leaf throws back chiefly green rays; the rest are absorbed. So, the natural color of everything in nature is the unabsorbed residue from full white light. There is no such thing as color by itself.

A swarm of minute particles, scattered in the path of white light, will break it up, like the surface of mother-of-pearl. If the particles happen to be of just the right size and the spaces between them just the right distance, they will absorb rays of one color only and throw off the rest. The atmosphere is filled with countless dust particles, and their size and spacing is such that they scatter rays which we call sky blue. Nearer the horizon, larger particles turn the blue into white; this happens above a dusty town and when mists or clouds hang above us. All that is left of white sunlight, after passing through many miles of blue-scattering air, appears in the hues of sunset. The size and spacing of dust particles as well as the angle at which sunlight strikes them, determines the color of the sky.

On the moon where there is no atmosphere and no dust, the sky is jet black at noon. The sun appears as a vividly glowing disk in an inky canopy. That is also true of the vast space which exists between the stars.

A Stairway Which Is Also a Door

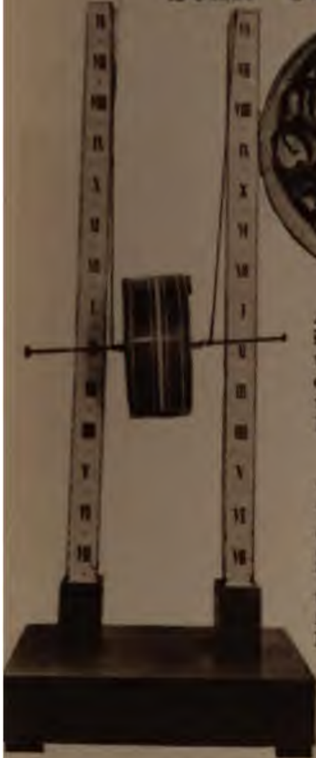
IN order to construct a stairway between floors in a limited space, a swinging stairway has been developed which does away with the usual double-



A stairway which has a hinged door section, by which the cellar or the upper floor can be reached with equal facility

width landing. The stairs are built with a hinge half way between the upper floor and the landing, the landing being half way between floors. The stairs from the landing to the floor are built directly beneath the others. A person descending, stops at the landing to disengage a small catch. The released catch allows the lower portion of the hinged stairs to fold upwards, so that the person passes underneath them to the lower staircase. A heavy weight makes it easy to lift the stairs when the catch is released.

Some Curious Clocks of Paris



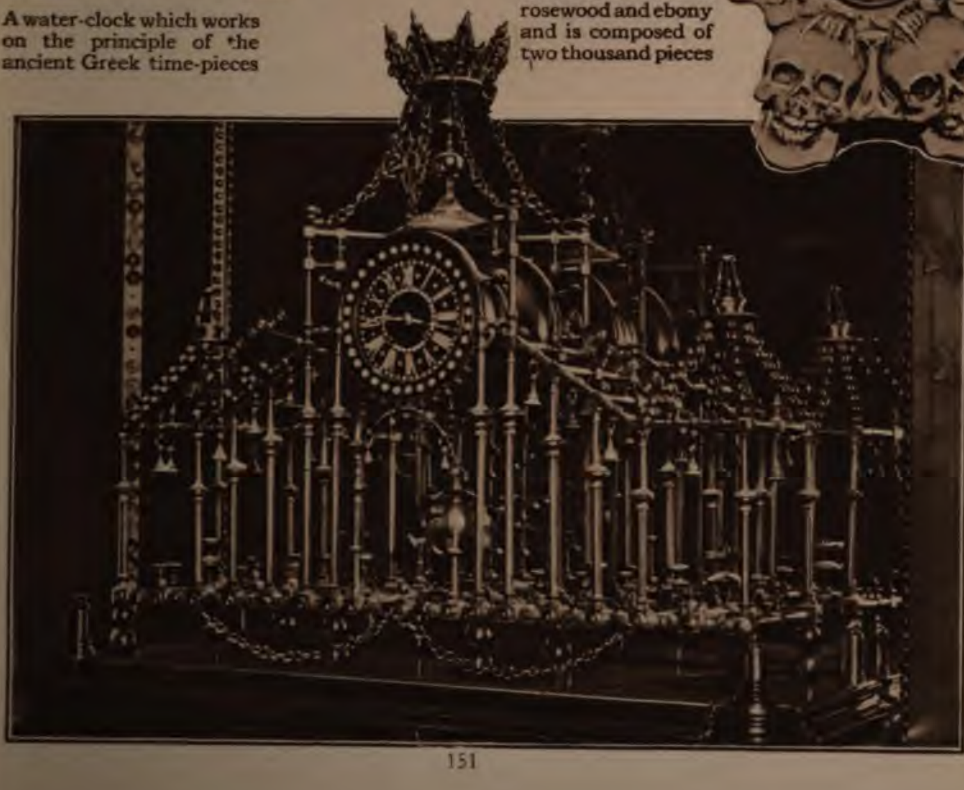
Above: The dial is a soup plate; the numerals are oyster shells; and the hands are a knife and a fork

To the right: The strange clock of a lead-pencil maker. The hands and the numerals are formed of huge lead-pencils

A clock surrounded by human teeth and resting on human skulls

The clock below, in a Parisian shop window, is made of rosewood and ebony and is composed of two thousand pieces

A water-clock which works on the principle of the ancient Greek time-pieces



What Makes an Electric Lamp-Bulb Glow?

WHEN you heat iron in a forge it becomes either red hot or white hot, depending on how hot it is. It sends forth light. The hotter it is the more light it gives. Finally there comes a point where the iron melts away.

The best light-giving material is that which will melt at the highest temperature. Carbon is a material which cannot be melted easily; but it burns up in the open air long before it reaches the melting point. Edison conceived the idea of making a little thread of carbon, of placing that thread in a bulb, and of heating it by the electric current to the highest possible point. In order to prevent the carbon filament from burning up he pumped out all the air in the bulb. The result was that the thread of carbon was heated to the glowing point, so that it gave a very bright light.

Tungsten is a metal which melts at the highest melting point. It ought to be the best light-producer, since it can be heated higher than any other metal without melting. The trouble is that tungsten is exceedingly brittle, so that a thread cannot easily be made of it. This difficulty was overcome about twelve years ago by making a paste of powdered tungsten and forming a thread of this paste. Later still a way was found of so treating the tungsten that it could be drawn into a hair-like thread a mile long if necessary. All modern electric incandescent lamps have such tungsten filaments. They consume very much less current than the older carbon-filament lamps and give a much whiter light, simply because tungsten can be heated so very much before it melts.

THE Department of Agriculture asserts that on the average farm a flock of one hundred to one hundred and fifty hens is more easily made profitable than a flock of one thousand.

A Top That Never Stops Spinning

ELECTRICITY has invaded the young boy's field of sportsmanship. The record spin in the game of whose-top-can-stay-up-longest has been shattered so badly that the cord-spun top, in comparison, really does not spin at all.

A top which will keep on spinning forever —or until its battery wears out. It affords indeed "endless" amusement

Like most other things that electricity takes a hand in, the electrical top does not topple after a mere spin; it whirls on for hours, according to the desire of its youthful operator. The top, in reality, is a miniature electric motor turned on end. In place of the steel peg and the sidewalk, there is a steel shaft which revolves in a bearing, and instead of the wooden pear-shaped body, there is an iron armature wound with wire. At the top of the shaft varied colored disks are placed. When the current from a dry battery is turned on, the shaft revolves and the disks spin, giving a pleasing effect in rainbow colors.

A Quaint Cypress Tree Village in Paris

Above, a church, summer-house and various birds fashioned from cypress trees. This has been called the most curious garden in the world

At right, a seven-storied tower which looks substantial enough to be tenanted. It took the gardener several years to bring this to perfection

Above, a well surrounded by a wall of cypress carefully trimmed to retain its shape and growth. This was not so difficult to accomplish

Below, an elaborate and delicate "umbrella tree." Wires are used as a supporting structure for the abundant foliage The tree trunk is a pole

Just How You Wear Out Your Clothes

WE speak, and speak correctly, of "wearing a suit of clothes" when we have in mind only the use of the clothes; but the garments are literally worn away. We might also speak of "wearing" bed-clothes, because the fibers of the bed linen are worn away in much the same manner as a carpenter wears away the surface of wood when he sand-papers it. Draughts and other air currents waft these fibers to and fro until they collect in small clusters of "fluff." The "bits and cantles" that have begun to attract others to them gather more and more, until a large proportion of the aerial flotsam has been transformed into what the housekeeper calls "little rolls of dust" that she finds under the bed and in the corners. These are fibers that friction has removed from the bed linen and from one's clothing.

Small clusters of "fluff" blown into what the housekeeper calls rolls of dust

Whenever cloth is handled, some fibers are rubbed off and in time become visible and objectionable. The formation of this fluff is not unlike the growth of snowballs that boys roll.

Under the microscope, especially with reflected light, these balls of fluff are wonderfully beautiful, gleaming with a brilliancy that cannot be captured by a photograph.

A New Check Protector No Bigger Than a Pocket Match-Safe

A NEW check protector has just been invented by an Oakland, California, man. It is so small and compact that it resembles a pocket cigar-lighter and can be carried in a vest pocket as easily as a match-safe.

It consists of a metal holder, at one end of which is inserted a round steel die, containing hatched lines. This steel die revolves and its surface comes in contact with an ink pad placed inside the holder. The check to be protected is placed upon a small corrugated aluminum board, furnished for the purpose, and then the hatched wheel of the protector is brought into position on the surface of the check, over the written amount. With a slight pressure the wheel is slowly revolved across the face of the check.

The revolving wheel both prints and perforates the paper, following the grooves of the aluminum sheet underneath. The result is a series of printed, and perforated hatched lines, in a faint-colored ink, which does not interfere with the legibility of the writing but does prevent any erasures or changes.

The chief advantage of the new protector is its size.

A small, compact instrument for preventing the erasure of signatures on checks

Repairing the Human Wrecks of War

An idea of the enormous number of casualties on the battlefields may be obtained from this glimpse of a German storehouse containing splints for wounded arms and legs

The mental unrest of the disabled men is eased by encouraging them to make trinkets of empty shells and cartridges

An artificial sunbath of ltra-violet rays which is being used by German military hospital for healing

A repair for frozen fingers—a glove with elastic bands which stretches the fingers and thus hastens the cure

Protecting the Ears from the Shock of Great Guns

SPECIALISTS on nervous disorders tell us that the noises of concussions, trains, fog horns, gun reports, the clash of machinery and other harsh or prolonged sounds wear away the energy of the nervous system, shock by shock, causing headaches, deafness, fatigue and debility. An ear-protector, then, designed to modify the sound vibrations before they can be communicated to the organs of the internal ear, would seem to be a very necessary thing in some walks of life.

The device is a guard, not a stopper, and does not interfere with the circulation of air in the canal of the ear

One which has been placed on the market recently is made of transparent material and has two soft rubber disks. One of these disks is small and thin and fits into the canal of the ear adjusting itself to any size ear. The other disk is larger and thicker and covers the orifice of the canal, preventing the protector from going in too far.

The device is a guard, not a stopper, and does not interfere with the natural circulation of air in the canal of the ear. The atmospheric pressure is kept normal and sounds of moderate force enter the ear without change. Only those sounds which are of sufficient strength or of such character as to produce shock are modified. The protector is also useful in keeping the ears free from dust and for excluding wind and water.

There are several of the ear-protectors and shock absorbers on the market. The demand for them has been increased by the war, so many of the soldiers having been deafened from the noise of explosions and bursting shells. Wherever there is a special demand for any article there are always special efforts to improve on the existing models so that a person may take his choice of almost any number of kinds. The type which has been adopted recently by the British Admiralty for use in the Navy is shown in the photograph at the bottom of the page. The neat little box holds a pair of shock-absorbers and fits into the vest pocket as easily as a pill-box. The principle involved is the same as in the first illustration. There are two sound-stops, one in front and the other in back of a sensitive diaphragm. These effectually prevent any violent shock from passing on to the inner ear. The stops and the diaphragm are held in place by washers. The device can neither go in too far nor drop out of the ears accidentally.

It has been found that soldiers using these ear-protectors are stronger physically and less inclined to suffer from digestive disorders on account of the better condition of the nervous system. Residents of rural districts visiting in one of our modern cities, and even the long-suffering city-dweller accustomed to the noise might also value the shock-absorbers.


The type of ear-protector which has been adopted by the British Admiralty for use in the Navy

Why Can't We Make Diamonds

WE can. But they are so small that a microscope has to be used to see them. There is no chemical difference between the graphite in your pencil, the coal in the kitchen stove and the diamond. All are forms of carbon, and the diamond is but crystallized carbon. The Kohinoor that blazes in the diadem of a potentate was crystallized by nature from something like coal.

Molten iron will dissolve carbon, just as sugar is dissolved in water. Like water it chills and solidifies when it expands. A French physicist, Moissan, heated a crucible containing a mixture of pure iron and carbon to a temperature of seven thousand degrees Fahr. He dropped the white-hot crucible into cold water. The resulting contraction produced great pressure, and in that pressure diamonds were formed, not Kohinoors, but microscopic crystals, each of which cost about five times as much as a natural diamond of equal size. Sir William Crookes, the distinguished English chemist, obtained minute diamonds also by combining great heat with great pressure. He exploded cordite, to which carbon had been added, in a closed chamber. In other words he used a kind of cannon the mouth of which had been sealed. If we are to make big, salable diamonds we must have far more powerful mechanism at our disposal. Some day that mechanism will be provided, and the diamond factory of Niagara Falls will compete with the Kimberley Mines of South Africa.

A Lace Curtain Protection

IN the summer, when the windows are opened, the housewife may be annoyed by the fact that the lace curtains blow against the screens, and become rusty and dirty. This can be avoided by placing a small tack at each side of the window and tying a piece of white cord from one tack, across to the other. This will keep the c rtains clean.

When a person sits near the window he may be bothered by the curtain blowing against him. Now, if another piece of string is placed exactly where the first piece was, and the curtain is placed between the two, it will be kept there; and both difficulties will be solved.

Eliminating Pottery Waste

POTTERY-MAKING has been, until recently, one of the few remaining industries where the skilled workman held absolute sway. And even with the most skilled of firemen, the variation in the degree of heat in the kilns was still so great that the loss in ruined pottery and "seconds" was immensely high.

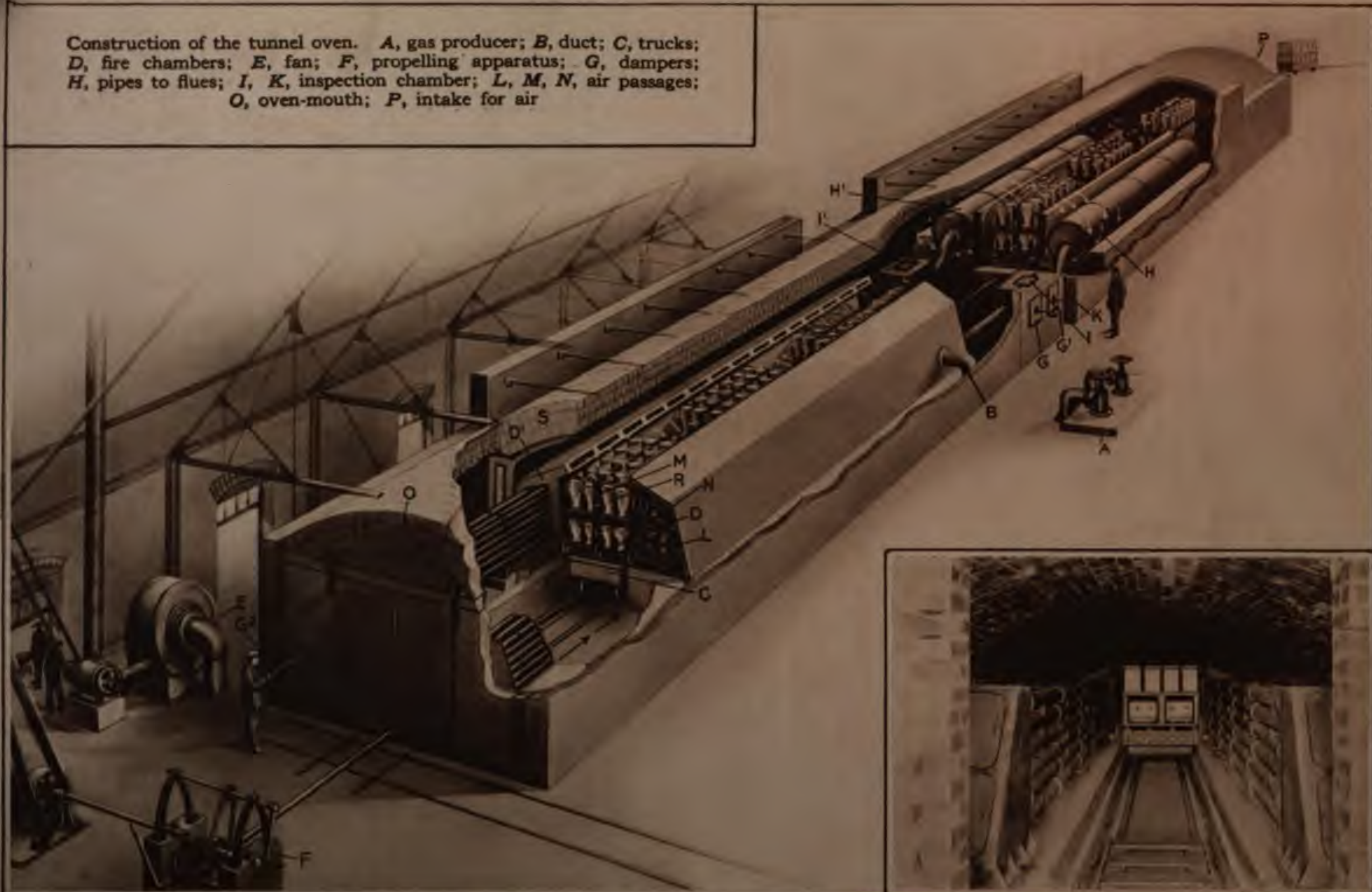
Not long ago an Englishman, Conrad Dressler, invented, for use in the glazing of wall tiles, a tunnel-kiln in which small carloads of material could be fired at once, and in which, by means of the generation of the heat from gas-producers, a saving in fuel up to eighty per cent could be affected. Not only this; but the temperature was kept so even that the wastage from ruined tiles and "seconds" was eliminated almost entirely, and the whole device could be controlled by unskilled workmen.

The oven has recently been applied to the kindred art of pottery-making, and in several large plants has taken the place of the old ovens, with vast saving to the company, though perhaps delivering a blow to that notable American industry, the five-and-ten-cent-store, where "seconds" delight the economical.

In pottery the clay bodies are changed in chemical and physical structure at a temperature varying from two thousand to twenty-five hundred degrees Fahrenheit, and to fall short of this temperature or to increase it unduly for any length of time, is to spoil the merchandise.

The gas from the producer enters the tunnel-kiln and is burnt, not among the wares to be baked, but in two long tubes running lengthwise of the tunnel, from which the fumes are carried off outside the kiln. The control of gas and air for its combustion is regulated automatically or at will, and is thoroughly even. The goods to be fired are put on the trucks, and propelled by a small motor, taking about one hour for the trip, not including the cooling in a heated chamber.

This kiln was first used in this country by a manufacturer of sanitary porcelain ware, and the scene reproduced here is from this American plant. The goods, in all cases, are placed on the shelves of trucks, which commence at two feet from the ground and rise to five feet for their trip through the long kiln.



Construction of the tunnel oven. *A*, gas producer; *B*, duct; *C*, trucks; *D*, fire chambers; *E*, fan; *F*, propelling apparatus; *G*, dampers; *H*, pipes to flues; *I*, *K*, inspection chamber; *L*, *M*, *N*, air passages; *O*, oven-mouth; *P*, intake for air

A Pottery Furnace built like a railroad terminal with real cars and tracks

Teaching Blind Men to Fence

IN FRANCE, the only country where fencing can be said to flourish, a new system for teaching the use of the foil to blind men has sprung up. Its originator, Georges Dubois, has a method whereby the student is taught to rely upon the sense of touch only. In all fencing methods the sense of sight is not wholly relied upon. Professor Dubois emphasizes touch and eliminates sight altogether.

The white strips on the ground enable the student to assume his position

Soldiers, blinded in war, have now an opportunity of becoming skilled in the use of that ancient weapon, the small-sword. A blind man's one advantage is his ability to concentrate his attention without being distracted by seeing the action of others. This is of great value in modern fencing where a single "touch" anywhere on the body means that the bout is over. Intense alertness is requisite from the moment the fencer puts himself "on guard."

In the circle is shown Professor Dubois placing the pommel, or end of the handle, against the student's wrist. If the pommel is in the center of the wrist, the blade is in line with the arm. The blind students practice "binding," by twisting their blades over their opponent's and thrusting at the same time. This play is mainly for thrusting under the shoulder, accomplished by twisting the foil.

Making a successful thrust is the test of a blind man's training

Blind students are taught the feeling of an opponent's sword by means of iron rods

Plenty of Room for All Europe

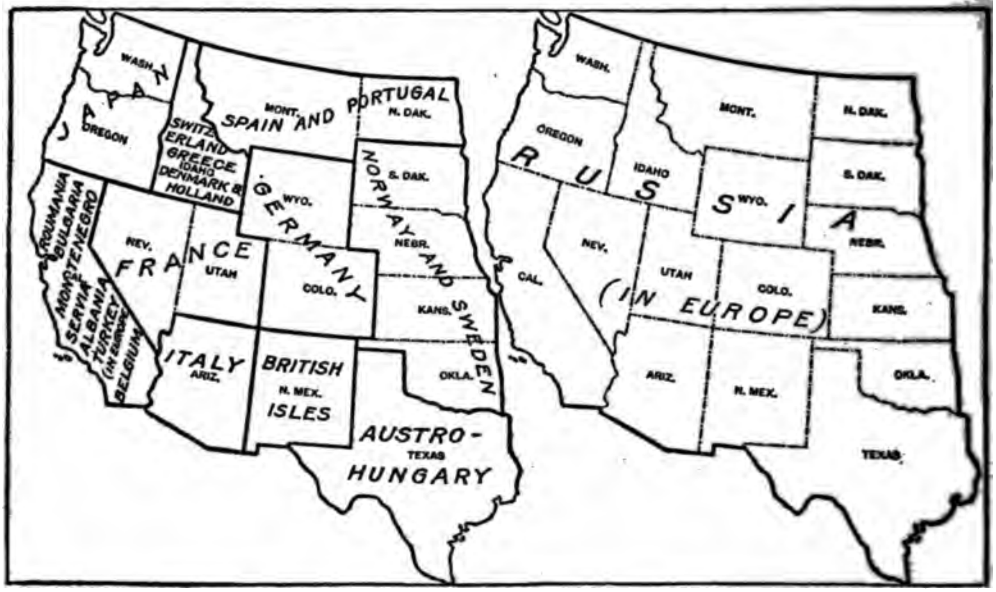
THE United States can swallow all of Europe—area, population and all—as will be seen in the accompanying map, which shows in a vivid manner how wide is the expanse of the country we live in.

The entire combined computed area of the foreign countries noted on the map and the area of the western United States are very nearly the same. The discrepancy is a bare fifteen thousand square miles on Europe's side. At the same time, however, Russia in Europe would spread over the whole western part of our country, crowding it to the doors with its one hundred and eleven millions of people, being the largest of all the European countries.

The State of California has ample quarters for seven European countries, but its population is only a little over two millions, whereas little Roumania alone harbors just about seven million inhabitants.

Austro-Hungary fits rather tightly across the shoulders in Texas, which has a scattered population of nearly four millions, whereas Austro-Hungary has more than fifty-one millions of people accommodated within its boundaries.

More striking, however, is corpulent Idaho with its three hundred and twenty-five thousand inhabitants living in an area sufficient to quarter sixteen millions of Europeans living in four large countries. Then there are Montana and North Dakota with their nine hundred thousand people enjoying enough room for Spain and Portugal's twenty-five millions.



A Map Showing How Snugly the Different European Countries Would Fit into the Western United States, Mighty Russia Occupying As Much Space As All the Other Countries Combined

New American Porcelain Utensils a Result of the War

ONE of the results of the war was the stoppage of the importation of laboratory porcelain, and this has resulted in the manufacture of laboratory porcelain in this country, which has stood the hydrochloric acid tests equally well with that manufactured by the royal Berlin pottery in Germany, which until now has been regarded as the standard.

The cooking porcelain ware is being produced in ivory, white, brown betty, and olive green, plain and decorated, and for private ward work the pretty decorations and delicacy of the ware make the porcelain highly attractive.

Experimenting with the Siphon

A SIMPLY-constructed siphon offers a most fertile field for amateur experimentation. In some cases water can be made to flow straight up twenty feet into the air until it passes the curve in the siphon and flows down again.

Two tumblers, one higher than the other, joined by glass tubing, can be used to demonstrate the siphon principle

The water will easily flow to a height of six feet with the apparatus shown at the right

To carry on a series of experiments all the apparatus needed is a piece of glass-tubing and a connected piece of rubber-tubing. The glass tube may be bent in an alcohol flame, and a siphon so constructed that it will take water upward for six feet or more, and then downward in the other arm. If the joints are made tight the water will flow even higher. When the water has passed from one vessel into the other, the lower vessel may be raised, and back the water will flow, thus running uphill and downhill. The only difficulty in this experiment, aside from making the joints tight, is to fill the pipe at the start. This may be done by filling the entire pipe when the parts are all on the same level. The ends may then be stopped and the one end raised into a perpendicular position.

But with all siphons of this kind the trouble is to establish a permanent conduit between the two receptacles, since the siphon will exhaust itself unless the higher vessel is always kept filled. A siphon will not wait for a fresh supply of water, but will empty itself and cease to act.

Recently one experimenter was obliged to devise a means whereby the siphon would hold its contents and wait for a fresh supply. This was accomplished by turning up one or both ends of the siphon. By this method a series of aquaria was connected so that water would run through the tubing and wait for a supply; that is, a tiny stream would keep the supply to the siphon running continuously, and the siphon would hold the water running at a permanent height.

Theoretically it is the push and not the pull that causes the water to run. The pressure of the air on the surface of the water in the upper vessel pushes the water up to take the place of what would be a vacuum. The action is similar to the pull on the part of two pulleys, in which one is heavier than the other. It is evident that the heavier weight pulls up the lighter. So it is with the siphon. The curved angle of the siphon takes the place of the pulley, and the long arm full of water takes the place of the heavier weight. Once the long arm full of water starts it "pulls" the contents of the shorter arm.

How the glass tubing is arranged when two large jars of water are to be siphoned. The test may be carried on indefinitely by reversing the position of the tubes

Forty Miles an Hour on the Water

Forty miles an hour is the claim of the inventor of this craft, which partially rises out of the water when it is under full speed

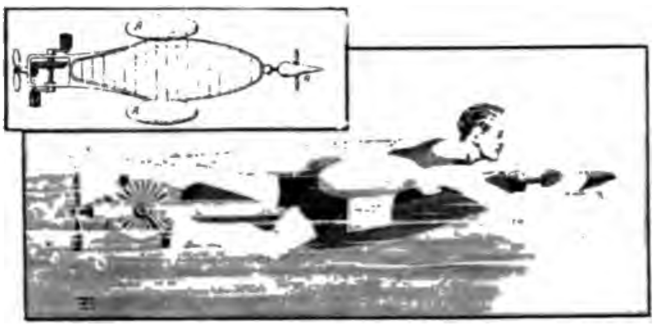
A BOAT has been designed by D. N. Brown, of Grand Haven, Mich., which, on test runs, has attained a speed of forty miles an hour. The body of the craft is made of thin galvanized iron over a basswood framework two feet wide and twenty feet long. Two galvanized iron air-tanks are attached to an outrigger five feet from the rear end on both sides. When the four-cylinder motor, set in the rear, whirls a six-inch propeller, the prow rises out of the water and the craft skims along like a huge bird over the surface, the entire weight resting on about three feet of the stern. The two tanks maintain the equilibrium.

The boat has proved a success in all ways and the inventor believes, with an improved design, that he will have a craft capable of making sixty miles an hour without being crowded.

It is evident that the inventor reduces skin friction as much as he can, for which reason he is able to travel at high speed in his boat.

What Ho! The Jitney Yacht

THAT every man who runs may cruise the seven seas, a jitney yacht has been evolved. It is indeed a peace ship—a one-piece—one man, semi-submersible. A glance at the anatomical chart appended, will explain the action of this rakish craft. Lie down comfortably upon the keel of the ship (which should be so laid as not to interfere unduly with any of your spinal peculiarities), grasp the conical rudder-control with both hands, set your gaze intently upon your goal and pedal for dear life.



The timid swimmer can now go through all the motions of swimming while being supported by a concealed water-bicycle

The rudder is a ball and socket affair that will steer the ship in any direction in the water. The pedal-propeller-gearing is at a two to one ratio to insure speed, and the pontoons *A A*, are inflated to the required buoyancy; *i. e.*, to float about one-third out of the water.

With a score of these one-man scouts darting across the water a battleship's squadron might anchor in perfect security and laugh at the deadly submarine. Or they might be hitched tandem, so that you may invite your fair lady to take the air on the ocean and save not only the carfare to the nearest beach, but bath-house hire as well.

New York is the World's Luxury Market

LONDON, the world's central market for the sale of luxuries of every description, has been practically closed and New York has taken its place. Custom House records show that the imports of the "luxury class" have increased enormously, particularly in the items of precious stones and works of art. As a single example, the American automobile industry's imports of crude rubber in the past year amounted to more than $111,000,000.

A captive balloon raised above the site of the proposed power plant between the White House and Washington Monument to show how high the stacks would come

Captive Balloon Teaches a Lesson

TO demonstrate to the residents of Washington and particularly to the members of Congress, just how unsightly the effect of the contemplated new power plant chimneys really may be, the experiment was made of floating a captive balloon over the site to a height equivalent to that of the completed chimneys. The effect was startling, since the balloon, when it attained the height of the proposed chimneys, had soared to an almost unbelievable height. Inasmuch as the new power plant with its undesirable chimneys will have an effect upon the new City Park plan, many people who watched the balloon experiment made up their minds that the chimneys should never be. The question is now under discussion among interested residents.

How Fast Is Your Train Moving?

A FAIRLY accurate computation of the speed of a moving train can be obtained by any keen-eared traveler with the aid of a watch equipped with a second hand. The wheels of a car produce a clacking in passing over the rail joints, the succession being divided into measures of as many beats as there are wheels on one side of the car. Furthermore, the traveler, due to his position, always hears one beat in each measure accented above the others. To determine the speed of the train, it is necessary only to count the accented beats for twenty seconds, the result being approximately the number of miles per hour of travel.

To explain this, let us say that fifty accented clicks are counted in the twenty seconds. Then the train is making about fifty miles per hour; for the fifty beats indicate that an equal number of rails have been passed over. The standard rail is thirty feet long. Hence fifteen hundred feet are being covered every one-third minute, or two hundred and seventy thousand feet per hour; which, divided by five thousand two hundred and eighty, gives fifty-one and one-seventh miles per hour as the actual speed. It will therefore be seen that the original count (number of beats in twenty seconds) comes close enough to serve the purpose.

When Should Children Be Held Upside Down?

GREATER love for children hath no man than the one who discovered that the lives of many little children can be saved in certain emergencies, if they are held upside down.

Held upside down, the child's face is safe from the flames

When the clothing of children catches fire if a third of the child's flesh is burned, inclusive of its chest or head, it is very likely to die. Yet if the little one is held upside down immediately after its garments have caught fire, the child's life may be saved.

The three-year-old tomboy daughter of a United States Senator was playing a war game with some boys. They were gathered around a camp-fire when the wind carried an ember in her direction and set her clothes on fire. Corporal Hopkins, who had served in an emergency hospital, happened to be at hand.

He seized the little girl by her ankles and held her head down, not an instant too soon. The flames were just about to burn her bosom and curls. Flames have a tendency to rise and a child's face, hair, lungs, heart, and chest are the vital parts first endangered.

Another emergency which demands that the child be held upside down by its legs or feet, is when it swallows a fish-bone, a coin, or a piece of candy.

The coin tumbles out promptly

On the face of one hammer is a Maltese cross which is forced through the check when struck with the second hammer

Canceling Checks with a Hammer and Anvil

IN Cumberland County, Pennsylvania, one of the largest and wealthiest counties in the Keystone State, the Board of County Auditors still uses an ancient method of canceling all checks given in payment of bills by the county treasurer and by the treasurer of the Board of Poor Directors. The apparatus, shown in the accompanying photograph, generations old, is composed of a block of oak, fourteen inches high and ten in diameter, and two ordinary-looking hammers. On the face of one is a Maltese cross which is forced through the check when struck with the second hammer.

When this fifty-six-thousand-pound flywheel is spinning in the hold of a ship seasickness is prevented

Preventing Ships from Rolling by the Use of Giant Flywheels

TO travel over the roughest seas or through the most varying winds with no rolling or rocking of the craft is believed to be a coming possibility—if it has not already been achieved. The new principle has been applied to some of the smallest yachts and to aeroplanes and is now being extended to larger vessels.

The accompanying illustration shows the largest steel casting ever made for this new purpose. It weighs 56,000 pounds and is 10 feet in diameter and 27 inches thick on its face. Two of these are now being installed on a United States army transport. They constitute the principal part of what is termed a gyroscopic stabilizer.

The mechanism depends for its success on the fact that when revolving at a high rate of speed, the usual motion imparted to a vessel by the waves is offset by this revolving mass. This particular casting revolves 1150 times per minute.

The Sidewalk Coaster Becomes an Automobile

A MECHANICAL cross-breed between the motorcycle and the boy's sidewalk coaster, is the one-passenger motor vehicle practically a motor-driven platform, illustrated below. Its pressed steel platform suspended four inches from the ground between wheels is fitted with pneumatic tires. The motor is attached to the front wheel and provides ample power to meet all road conditions.

The fact that you stand in driving the vehicle and the further fact that your weight is carried between the wheel centers, makes it very easy to balance the machine. There is practically nothing to watch but the handlebar which supports the rider and steers and controls the operation and speed of the machine. Both brake and clutch are operated by moving the handlebar forward or backward.

The machine is intended primarily for short distances but enough gasoline can be carried in the tank for a trip of one hundred miles. The speed can be increased to twenty-five miles an hour.

The handlebar controls the speed of the machine, steers it and operates the brake and the clutch

Your Mainsail and the Wind

Photo by Levick

The boom makes an angle with the boat to secure the highest possible speed

AN interesting and practical series of experiments in a field that is new to science has been made at the Massachusetts Institute of Technology by Professor H. A. Everett, for the purpose of determining some of the facts about the propelling power of sails. By dint of experience and by rule of thumb certain practices are common in sailing boats. Skippers agree in the main about these practices, but there are individual variations from any rule. Each man maintains and asserts that his is the proper way. What Professor Everett has done is to determine scientifically certain elements common to all sails with regard to thrust or propelling power, and twist, and to establish certain fundamental principles which fix the relations of sails to direction of the wind.

In Boston Professor Everett was

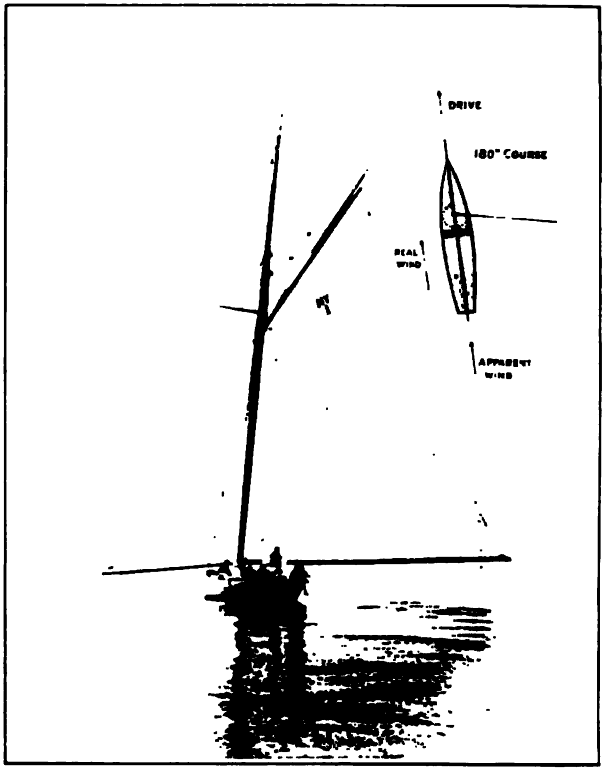
Photos by Levick

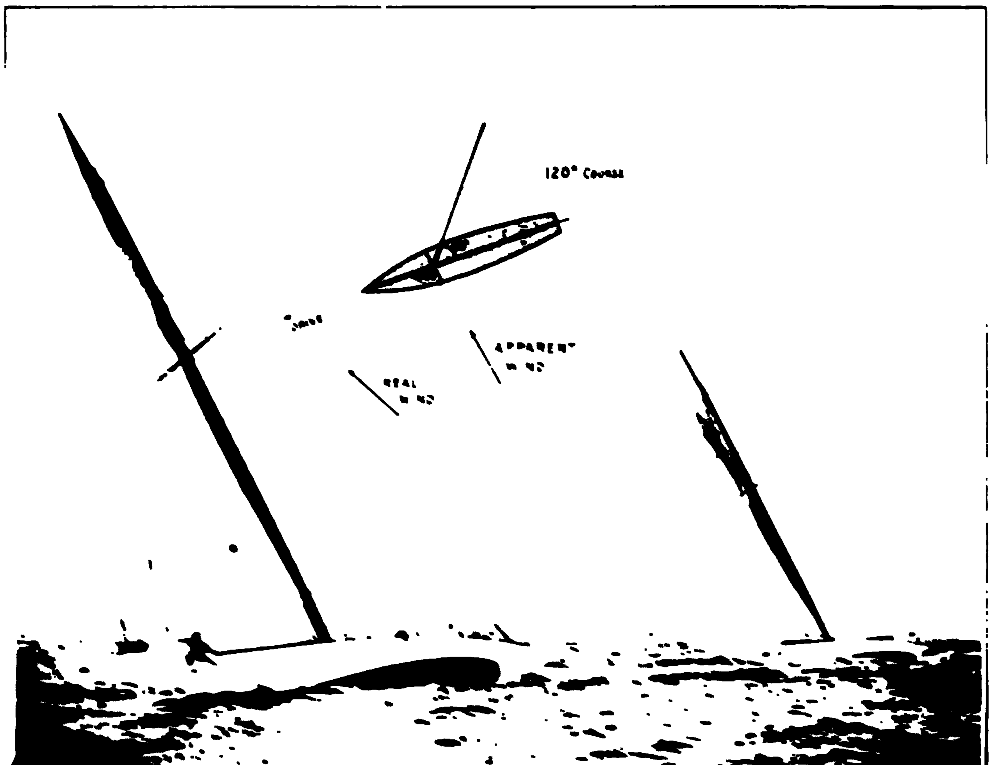
The wind which is customarily observed is that indicated by the fly at the masthead. The fly generally shows the skipper the apparent direction in which the wind is blowing. Professor Everett made experiments in a wind tunnel which show that yachtsmen do not fully appreciate the mechanical forces at work

The apparent wind is the resultant of the speed of the boat and the true wind

Assuming that the hull resistance is not affected by different angles of keel, the course at 190° with the wind is the one in which the boat will make the fastest headway. In the wind tunnel of the laboratory the construction is such that uniformly moving currents of air without swirls in them blow against the object tested. The mast with its sail is set up within the tunnel, and the effect of the wind in the sail is measured. The sail is set at different angles to the direction of the current of air

For courses from 45° to 160° the angle between the boom and center line of ship should be one half the angle between the fly and center line of ship. In the wind tunnel measurements are made at each angle of the direction of the current of air. The thrust and twist are measured, the experiments being repeated many times with different wind velocities. It is the apparent direction of the wind that concerns the sailing man





much in demand by naval organizations. Since last September he has been professor at the United States Naval Academy at Annapolis.

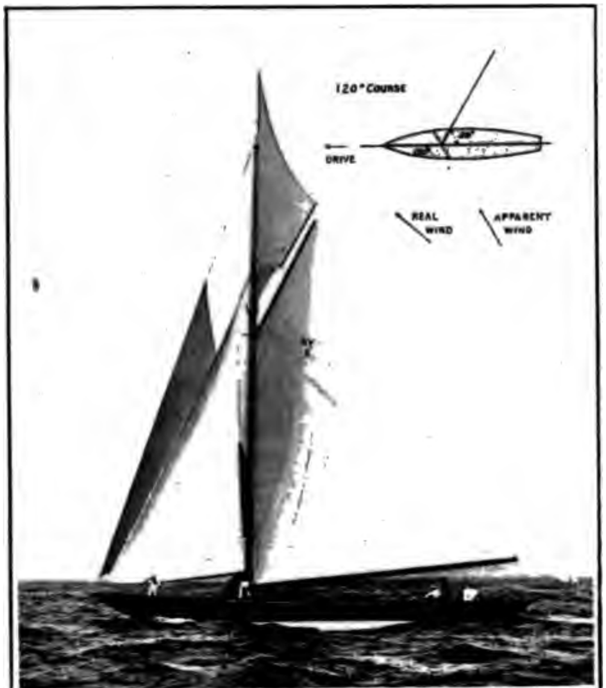
The underlying reason for the experiments was that the Institute has within three or four years established courses in aërodynamics, for the purpose of familiarizing young men with the design and construction of aeroplanes and airships. For the laboratory work in connection with these courses the Institute has had installed a wind-tunnel and accompanying equipment.

The tunnel is one of the important ones of the world and is equipped with an "aërodynamical balance" unique in this country. There is only one like it in the world. The Institute is therefore prepared to work on the scientific features of wind-currents. Hitherto such tunnels have been employed for the testing of propellers and determining the pressures on bodies of different shapes. The knowledge thus gained is of great assistance in making airships of the least resistant form.

Professor Everett hit on the idea of using this tunnel to discover what is the effect on a sail when subjected to different winds. He has been able to tell where the center of pressure is located in a sail, the amount of pressure for a given wind velocity and the angle which the boom should make with the longitudinal axis of a boat.

The experiments were made with a single sail, a mainsail, copied exactly on a scale of ⅜ of an inch to the foot from a winning model of last season. The original was known to be a successful pattern and the miniature sail was carefully cut and made in precisely the same proportions as the large pattern.

In the experiments no attempt was made to reproduce the deck above which the sail would hang. Nor was a jib used.. Either of these would have introduced disturbances in the nature of deflections of the air-current, which would have injured the chance of getting accurate results.



Here the distinction between real wind and apparent wind is very close

Another variation from natural conditions in sailing was that the boom was fastened to the mast, but the gaff or upper boom was free to swing off into any angle to which the wind drove it. The sail was set by two halyards as on a yacht. It was attached to the boom and gaff by lacings, and the inner edge or luff was held in place against the mast by small brass rings.

In the wind-tunnel of the laboratory the construction is such that uniformly moving currents of air without swirls in them blow against the object tested. The mast with its sail was set up within the tunnel, and the effect of the wind on the sail was measured. The sail was set at different angles to the direction of the currents of air, and measurements were made at each angle.

It was shown that the angle between the boom and center line should be about half the angle between the fly and center line.

X-Rays: Samaritans of War

By A. M. Jungmann

The X-ray photographs that accompany this article are used through the courtesy of Dr. J. P. Hoguet, who obtained them from the Roentgenographic Department of the American Ambulance Hospital at Neuilly, France. The brilliant surgical work done by Dr. Hoguet during the first months of the war has made his name memorable in the base hospitals of France. Dr. Hoguet was one of the first American surgeons to volunteer his services to the Allies.—EDITOR.

IF it were not for the clear-seeing eye of the X-ray the suffering among the soldiers wounded in the great world war would be well nigh inconceivable. The X-ray not only penetrates the flesh and locates bullets or pieces of shrapnel casing, but it shows the exact condition of a fractured bone. The surgeon no longer has to resort to guess work. Nowadays, thanks to the X-ray, he knows.

The larger, permanent base hospitals are equipped with X-ray apparatus, but, of course, it has been impossible to install the apparatus in the many temporary hospitals, such as private residences, which have been turned into hospitals for use during the war. In order to give the soldiers in such hospitals the X-ray examination they require, the French have evolved the excellent idea of a traveling X-ray apparatus. The machine is mounted on a truck and driven from one hospital to another. The current is carried into the house by means of a long tube through which the wire is run. The spectacle presented by this device is similar to that seen when a vacuum cleaner is at work.

The travelling X-ray apparatus makes a call at each hospital once a week at a certain time. All soldiers requiring the examination are ready at that time and the examinations are made as systematically and rapidly as possible, because the visiting apparatus frequently is in such demand that minutes are precious.

Each soldier who has been examined has an X-ray photograph, showing his condition, hung beside his chart so the visiting surgeon can see at a glance the exact nature of his wound. These charts —an innovation in hospital practice— have been found to be great time savers whenever work is done in great haste, and wherever the same surgeons are not permanently in the hospital.

When the war first began it was generally believed that the modern rifle bullets would prove particularly humane. Wounds made by the high-speed pointed rifle bullet were thought to be easy to handle, because they were clean and did not have ragged openings. This might have been the case if the soldiers could have had an opportunity to keep their clothes clean. The rigors of life in the field and in the trenches have made personal cleanliness impossible, so that even rifle bullets carry infection into the wounds because they have had to pass through indescribably dirty clothing. Dr. Hoguet, who operated in France, tells of one man who was brought to a base hospital in November. When the soldier was being undressed preparatory to an operation, he exclaimed, "Thank the Lord, I am getting these clothes off at last! It's worth being wounded to be rid of them!" This man had started to the front when the war broke out and he had no opportunity to change his clothes from the day he left home until he was brought into the hospital in November. Under such circumstances it is easy to understand why a rifle bullet can infect a wound.

In the Russian-Japanese war, the Japanese suffered very little from infection. Their religious rule of never going into battle without putting on clean underwear, and their habit of frequent bathing, were largely responsible for this. But today the men who are fighting have no facilities for obeying the first principles of personal hygiene.

Wounds inflicted by shrapnel casing are particularly dangerous from the standpoint of infection. The uneven edges of the metal fragments are sure to

introduce bits of cloth into the wound, which almost invariably cause infection. The lead shrapnel balls also make bad wounds because of their size and because of their low velocity. They not only carry infectious material, but they make a bruised, lacerated wound, very different from that produced by high-speed rifle bullets.

A low velocity bullet, in other words a shrapnel ball, produced this wound. Before X-Rays were used on the battlefield, it would have been necessary to amputate the arm

The maximum muzzle speed of the German rifle bullet is about two thousand nine hundred feet per second. If such a bullet strikes a heavy bone it usually causes what is known as the butterfly fracture The bone is completely shattered. Sometimes a rifle bullet will go right through a heavy bone, making a clean perforation—a rare occurrence, however. Ordinarily, when a bullet traveling at high speed strikes a bone the resulting fracture not only destroys the bone at the point of contact, breaking it into small fragments, but the transmission of energy from the bullet causes the bone to crack. It has been found that long fissures are likely to appear above and below the place where the bone was hit.

If a man is hit by a bullet which has spent its greatest force, and that bullet strikes a bone, a fracture results which is comparable to the sort any peaceful industrial worker might sustain in an ordinary accident.

From observations made by surgeons in the various base hospitals it would seem that the most

Surgeons call this a "butterfly" fracture of the arm because of its appearance. The safety pins hold the bandage in place

Below the operating table is the X-Ray tube. The surgeon wears a fluoroscope. The X-Ray tube and the fluoroscope combined enable him to locate deep-seated bullets

severe wounds are those caused by shrapnel. The exploding shell is often imbedded in the flesh, and because of its low speed makes particularly ugly wounds, especially to the face and head. The effect of shrapnel balls is also exceedingly destructive when they come in contact with bones. They cause the bone to be broken into minute fragments, which gives rise to many complications. The shrapnel ball is solid lead, .50 caliber, and averages forty balls to the pound.

The fractures which give the most trouble are those of the leg at

Thanks to the X-Ray, this shrapnel ball lodged behind the eye, could be removed. Lead shrapnel balls make bad wounds because of their size and because of their low velocity. Sometimes they carry with them infectious material in passing through clothing

A foot (shown upturned) which has been injured by the fragments of a shrapnel shell casing

A refractory bullet which lodged dangerously close to the spinal column

or above the knee. These wounds become infected more readily than do similar ones in the arm. In order to save the patient's life, it is frequently necessary to amputate through the thigh at the earliest possible moment, because the infection travels upward with great rapidity.

In the case of bullet wounds in the arm, even when accompanied by a bad fracture and loss of considerable bone structure, there is always a greater chance of saving the arm than of saving a similarly wounded leg.

Ordinarily one does not associate the work of the dental surgeon with military surgery, but in the base hospitals in France the dental surgeons have done wonderful work. There have been many cases of terrible mutilation of the face and jaws by both rifle bullets and shrapnel, which would seem almost beyond human ability to repair. In these cases the work of the dental surgeons has been almost miraculous. They have performed miracles in cases where a large part of the bone was destroyed and where the mouth, chin and cheeks were seriously lacerated. In some instances patients have recovered from injuries where the side of the face was literally torn away.

Without the X-ray to determine the exact nature and extent of injuries of this type it would be impossible for the dental surgeon to achieve the results he has accomplished. He must know beyond a doubt just how extensive is the injury to the bone structure before he can undertake his work of restoration. In some instances soldiers have been given what amounts to practically a new face. No matter how bad the facial wounds, if a man lives, he need not fear serious disfigurement. The skill and ingenuity of the modern dental surgeon will send him from the hospital presentable in appearance.

It is now thought that the charges on each side that dum-dum bullets were being used was caused by the peculiar effect of what has come to be known as a "ricochet" bullet. This is a bullet which has struck a very hard substance with such force that it burst its jacket and then rebounded and hit a soldier. The X-ray has revealed many such "ricochet" bullets. They make a large wound, much lacerated and bruised.

The hospital ships are equipped with X-ray plants so the soldiers may be examined and their wounds properly cared for while they are being transported from one point to another. Many of the ships are also well provided with operating rooms so that urgent cases do not have to wait until they reach a base hospital. The X-ray photographs taken on board the hospital ships are sent with the soldiers to the base hospitals. This gives the surgeons at the base hospitals a complete understanding of the nature of the case the moment they examine the patient's chart and photograph. The X-ray photographs so used do away with tedious examinations, painful to the patient and trying to the surgeon. No wonder that the military surgeon's most trustworthy and able assistant is the X-ray.

German Textile Industries in War Time

Within the period of January to May, 1915, inclusive, one hundred and ninety-three German textile concerns have published their reports for the business year 1914. The aggregate gross earnings of these concerns reached, for each one thousand-dollar capital stock, two hundred and seventeen dollars, as against two hundred and six dollars, in 1913. Gross earnings have, therefore, increased in 1914, because the surplus for the business year has increased from two hundred and seventy-four dollars to two hundred and eighty-six dollars, and net earnings from five hundred and fifty-two dollars to five hundred and eighty-three dollars for each one thousand-dollar capital stock, compared with 1913.

In spite of increased earnings and surplus, dividends have decreased, the average dividend for 1914 reaching seven and six-tenths per cent, as against eight and one-half per cent in 1913.

American Aeroplanes for Spain

Another neutral European nation to order aeroplanes from the United States is Spain. A few weeks after the shipment of a number of flying machines to Holland, twenty Curtiss aeroplanes were sent to Spain, via Gibraltar. A. J. Engle, a Curtiss instructor, will instruct the officers of the Spanish Flying Corps and establish a military flying school.

Chinese Doctors and Their Ways

By Franz Otto Koch

A Chinese street doctor examining hair from several youthful callers. The physician diagnoses a disease from a patient's hair and then proceeds to drive his needles

THE native Chinese doctor is a curiosity. He passes no examination; he requires no qualifications; he may have failed in business and set up as a physician. In his new profession he requires little stock in trade, medical instruments being almost unknown.

Acupuncture, as it is called, is one of the nine branches recognized in medical science among the Chinese; it is of most ancient origin, having been in use from time immemorial. There are three hundred and thirty-seven body markings to be learned; every square inch on the human surface has its own name, and some relationship to the internal parts, purely imaginary, is assigned to it. The user is cautioned against wounding the arteries; hence he must know the position of the blood vessels. By close study of a manikin pierced with holes, the Chinese physician learns where to drive his needles. Parts of the body are selected, which may be pierced without fatal results. Sometimes heat is applied to the outer end of the needle and this is called hot acupuncture, but the needle is never heated before insertion. In some cases the needle has been known to break in the body of the patient and has had to remain there until extracted by some skillful Western practitioner.

The needle used looks very much like a sewing-machine needle, but it is longer and coarser. Some of the Chinese doctors have needles two feet long, and are supposed, by ardent admirers, to be able to drive these instruments entirely through the patient's body. The great size of the needles is in reality intended to represent the greatness of the owner's skill and reputation. The needles used

whose father has been a doctor before him. Confidence in him knows no bounds should his grandfather have followed the same calling. This is not a mere fatuous belief in heredity, but is based on the supposed value of old prescription books passed on from grandfather to grandson.

At left, the attractive and decorative office of a prosperous Chinese physician in Peking. Below, drying medicinal herbs in a Shanghai courtyard. These are later made into medicine

are of eight forms, as follows the arrow-head, blunt puncturing, spear-pointed, fusiform, round, capillary, long and thick. The point of insertion, the depth and the direction are all-important. The method is usually to drive the needle through the distended skin by a blow from a light mallet.

If he can get an old book of prescriptions from a retiring practitioner, so much the better for the Chinese doctor. He is now equipped to kill or cure, as chance or his ignorance may dictate. The doctor most entitled to confidence in the sight of his countrymen is the man

Acupuncture. The skin is punctured with a needle until in some spots it has as many holes as a sieve

Fees vary according to the physician's social class and that of his patients, and also according to the physician's place of residence. The enormous sum of perhaps fifteen American cents or half a dollar at the most may be charged for a visit, if the doctor comes in his sedan chair. Of this amount, a large proportion goes for the chair. Should the doctor belong to the humbler ranks and come on foot, his fee is proportionately less. He assumes a solemn air and an owl-like look as he peers out of the semi-darkness

A choice assortment of medicinal roots soaking in a Chinese drug shop prior to their conversion into drugs

A Peking street dentist ready to do business. The monkey is his trade sign

The Chief instruments of a Chinese doctor, including a pair of scissors, a large knife and a straw hat which signifies prosperity

Doctoring the nose with a few drops of herb medicine on the end of a needle. Sometimes the needle is driven with a mallet

of a Chinese bedroom through great goggle-shaped glasses—two inches across and set in huge uncouth copper frames.

Most important in diagnosing a case, according to Chinese ideas, is the feeling of the different pulses of the human system. The pulse at each wrist is felt, and each is divided into three, which according to the light or heavy character of the pressure, indicates a different organ of the body. By thus feeling the pulses, the states of a dozen real or imaginary organs are determined. Having then learned by the pressure of these three at each pulse, the seat of the disease, a few questions may be asked, but these are considered scarcely necessary. A prescription, sometimes calling for the most horrible and nauseating compounds, is prepared in large doses; for the native believes that the larger the dose, the more likely is it to prove efficacious. In prescribing for natives, the foreign doctors have to give the strictest injunctions that the paper box in which the pills are contained is not to be swallowed.

Among Chinese medicines, besides some that are to be found in our Western *Materia Medica*, are snake skins, fossils, rhinoceros or hartshorn shavings, silk-worms, asbestos, moths, oyster shells, and other things. Almost anything disgusting is considered a good medicine. Apothecaries' shops abound where prescriptions are made up.

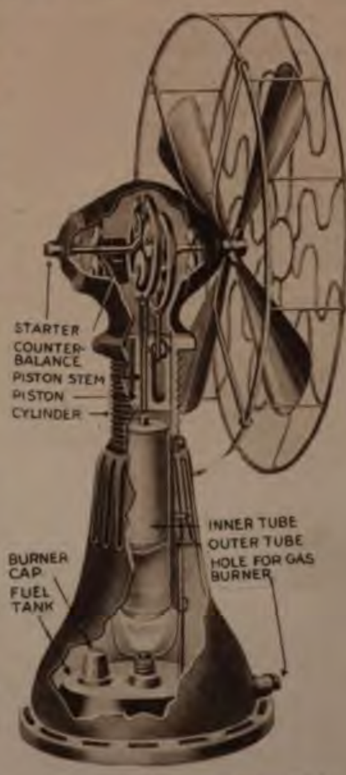
The manner in which the Chinese treat their physicians is characteristic. Should a speedy cure not result from the doctor's treatment, the patient calls in another. If he does not improve, he calls in a third. Thus the medical skill of the whole neighborhood may be drawn upon.

Keeping Cool with a Fan Driven by a Hot-Air Engine

SUMMER and electric fans go well together, but where electricity is not to be had people have had to forego such pleasures. They will not be obliged to go without their summer breezes any more, however, for the little fan illustrated can be used any place where a connection can be made to gas or where alcohol can be purchased.

The fan is operated by a small hot-air engine in which all the rotating parts are carefully adjusted and balanced so that it runs smoothly and evenly, driving the blades at a speed sufficient to send forth a breeze that will lower the temperature on the hottest day.

The operation of the fan is interesting. The air in the lower end of the cylinder is heated by the lamp and expanding drives the piston upward, revolving the fan and creating a momentum. This cycle of operations continues, the fan gaining in speed with each revolution, and continuing to run as long as the fuel holds out. When gas is not to be had, denatured alcohol will serve as the fuel. In many cases the cost of operation is not more than one half cent an hour, and the fuel tank will hold sufficient fuel for twenty-four hours' running.



The fan is run by gas or denatured alcohol. It costs about one half cent an hour to operate it

The Latest in Golf Clubs

A PHILADELPHIAN has invented a "combination" golf club. A ratchet in the heel of the club makes the various angles possible. Give the ratchet a twist and you convert the club from a driver into a mid-iron, mashie, putter or niblick. The change is made in remarkably quick time, and it can be changed from a right- to a left-handed club without effort.

MARVELS OF NATURE

Not Candy but Moth and Butterfly Eggs

The marvelous forms and beautiful patterns of moth and butterfly eggs as revealed under the microscope. These artistic objects are obtained by covering the eggs with a bell glass before the larvae emerge. After the tiny larvae have crawled out, the fragile boxes are destroyed or mutilated by storms or winds. They retain their form better when occupied

Fish That Travel on Land

When the tide goes out and strands these fish in a shallow pool, they leave the water, and actually flop over land to the sea. They never get lost and travel in the wrong direction, but always take the straightest road back to deep water

SCIENTISTS rarely go a-fishing in troubled waters; Professor S. O. Mast, however, of the zoological department of Johns Hopkins, is an exception. The Johns Hopkins professor discovered that such fish as minnows are often found in the little temporary pools left in the sand by the tide, but rarely, if ever, after the water in such a tide is so low that the outlet is closed.

When the tide is falling, these fish—*fundulus majolisis,* the scientific name for them—swim out, somehow knowing when the tide is about to get so low that they might be trapped in the little pools in the sand. As the tide falls, they swim in and out of such tide-pools at short intervals. Thus, these fish avoid being trapped in the pools and killed when the little collections of water dry during low tide.

Professor Mast has observed that the outlets of such tiny pools may be closed while the tide rises, but if they should close while the tide is falling, the fish swim about rapidly in various directions to discover water. If they find none, they leave the water and actually flop over land to the sea. Professor Mast has seen scores and scores of these fish leave large pools and travel across sand-bars more than twelve feet wide and half a foot high. The fish nearly always leave the pools on the side towards the sea. They evidently remember the direction of the outlet and the direction from which they entered.

Curiously enough, they never make any mistakes in "walking" on dry land, either. Professor Mast never found one to take a wrong direction for any great distance. Although he admits that it is not yet definitely known how fish are guided in the right direction, it is certain that light reflected from the water is not a factor in this sense of direction.

Perhaps one of the most interesting discoveries made by the Johns Hopkins zoologist shows how fish can make their way on dry land.

Of course, locomotion on land by fish can be brought about only by successive leaps and jumps produced by rapid bending and wriggling of the body or side-swiping by the tail.

When trapped in a pool which rapidly dries up or evaporates, they swim about for a few minutes, then come closely to the edge of the water and swim up and down the side of the pool nearest to the sea. Finally a dense aggregation of fish forms in the outlet near the dam, and three minutes by the watch after they are shut in, they manage to climb out on the sand. They leave in groups of twelve and "march" like General Sherman to the sea. These fish are superior to some men in finding their way home.

As a Packer Let Us Recommend Mother Nature

The yellow water-lily bud (above) is about twice the size of a pinhead. The bud of an ordinary sycamore maple (below) is twice the size of the water-lily bud; but the method of protection is entirely different for each. The edges of the undeveloped water-lily leaf are rolled toward the center, while the sycamore maple suggests a handful of squeezed lettuce

This flounder changes his spots to suit his surroundings

The Masquerades of Fish

Protective coloration among the fishes has occupied the attention of scientists for centuries. Dr. Sumner, of the United States Bureau of Fisheries, recently made experiments with flounders at the famous aquarium at Naples, Italy. He found that these fish are able to make themselves inconspicuous against almost any background, and, unlike the leopard, can change their spots whenever they choose.

Not only were these particular flounders able to adapt themselves to the color of the background, but to the pattern and the texture as well. They assumed a very dark shade upon a black bottom and a very pale one on a white bottom. They took on one pattern for sandy bottom, and another one for fine gravel, and still a third when the bottom was covered with small stones. Variously painted glass strips were prepared and laid down for the fish to practice upon. Some were done in draught-board pattern and others in white "polka-dots" on a black ground.

A fish that did his best to look like polka dots

The fish did remarkably well considering that some of the patterns were previously unknown in their little circle of life. Their splotches of black, white, gray and brown approximated the pattern so well that very careful study was often necessary to trace the exact outline of the fish. It was also proved that the flounder has individuality that, in some cases, at least, is capable of cultivation. Some of the fishes have much greater power of adaptation than others. Certain of them acquire with practice the power of changing more rapidly than at first. The time necessary for a complete change of pattern or shade ranges from a few seconds to days.

This tree held a mountain sheep till he died and then grew around its horns

A Forest Tragedy

Two hunters, wandering through the dense forest along the boundary line between Northwestern Montana and Idaho, were surprised to see protruding from the trunk of a lofty white pine tree at an elevation of twelve feet from the ground, a large pair of Rocky Mountain sheep antlers firmly imbedded in the living tree. They carefully cut down the pine and removed the section containing the antlers. They found that the skull was imbedded in the trunk at a point where the diameter is twenty inches. They reached the conclusion that the right antler had been caught on the base of the tree when the pine was about nine inches in diameter. Thus the animal was made a prisoner, and, being unable to escape, perished. The length of the larger antler is twenty-six inches. It is in perfect condition, having apparently been protected by the foliage of the tree. By counting the rings, the tree was estimated to be one hundred years old.

Is this the Origin of Forcible Feeding?

Photo by Brownell

A remarkable photograph of a brown thrasher feeding her young. The mother bird gathers the food, eats and digests it, and then disgorges it into the mouth, thrusting it far down the throat of the young bird, whose digestive apparatus has not reached a stage of perfect development

"Great Fleas Have Little Fleas Upon Their Backs to Bite 'Em"

TO the naturalist or to any one accustomed to observe Nature closely, the fact is apparent that the problems of existence are proportionately the same in every form or stratum of life. Even the common housefly, which seemingly has nothing else to do but to crawl lazily over whatever is left uncovered and then go happily on its way, doing its best to bring about an affiliation between the clean and the unclean, occasionally meets its Nemesis in the form of a tiny crab-like creature which attaches itself to the fly's legs.

The tiny creature here seen under the microscope literally makes life an inferno for the housefly

These little creatures are known to the scientist as pseudo-scorpions, or chelifers. They may sometimes be found between the leaves of old books that have stood unused for a long time, and also beneath the bark of trees and in mosses.

Although they are called false scorpions they resemble the true scorpions closely in general structure except for their minute size. But they have no poison gland as the true scorpions have. They attach themselves to other insects also, but they seem to be the special pest of the houseflies. Scientists suppose that they seize the fly's leg and hold on until the fly dies, either worried or frightened to death by the undesirable presence. When the fly is dead the little creature feeds on the body.

It is interesting to watch them under the microscope. A simple hand-lens will show them up to advantage. They are extremely active, running sidewise and backwards and gyrating in curious and amusing ways. It is easy to imagine the annoyance it causes the fly, when one or more of the pests decide to join hands with it; for whatever other activities the chelifer may find it never loses its hold of what is to be its storehouse of food eventually.

For, as De Morgan says:

> "Great fleas have little fleas upon their backs to bite 'em;
> And little fleas have lesser fleas, and so ad infinitum.
> And the great fleas themselves, in turn, have greater fleas to go on;
> While these again, have greater still, and greater still, and so on."

Iridescent Fish-Eggs for Table Decoration

PERSONS living on the Atlantic coast, or visiting there during the summer, often wonder at the beauty of the various "berries" on seaweeds. Many a lover of the seashore, and of the beautiful, has gathered large quantities of these variegated objects. They are beautiful when artistically arranged in a glass receptacle so as to display the various colors, but they are not the fruit of a marine plant.

The eggs of the eighteen-spine sculpin arranged in a large jardinière for decorative purposes

On the contrary they are the eggs of the eighteen-spine sculpin and of other allied varieties of sculpins, and they furnish an excellent example of the astonishing profusion of material with which nature works along certain lines in the propagation of species. She seems to realize that many fish are fond of these eggs and she intends that there shall be no diminution in the number of sculpins. She acts accordingly.

Queer Denizens of the Deep.

Photograph by American Museum of Natural History

Above: A queer specimen of deep-sea fish which is about twelve inches long and has tentacle eyes each with a phosphorescent bulb attached. At left: A lobster with a double claw. Below is the special kind of louse which torments whales. What would the Popular Science Monthly not give for a picture of whale scratching himself!

Natural Cannonballs

[T]HE cannon balls illustrated are simply big, nearly spherical rocks [which] are found at intervals in the soft [sands]tone of Southern California, the

Natural cannon balls found in the soft sandstone of Southern California

sand formation in which the great [depos]its of petroleum are found. Of [cours]e there is no oil left in these cliffs; [it is] all leached out and evaporated, but [wher]e the strata dip down from two and to three thousand feet below [the su]rface, there it is saturated with oil [and n]atural gas, to constitute one of the [great]est oil deposits in the world.

The Devil's Post Pile

[T]HE Devil's Post Pile is one of the greatest wonders of America. It is a remarkable formation of volcanic [rock] that it has been constituted by [Presi]dential Proclamation a National Monument. [Th]e huge pile is composed [of l]arge basaltic columns [of] the dimensions of tel[egrap]h or telephone poles, [thoug]h most of them are [fou]r hexagonal or five-[sided]. Some, however, are [four-]sided and closely re[sembl]e hewn timbers about [two] feet in diameter. The ["post]s" stand in the pile at [all a]ngles from vertical to [almos]t horizontal.

[Th]e visible height of the [tallest] post is over fifty feet, [tho]ugh it is not known [how] far down they extend —a considerable distance it is believed by geologists. Each year's freezes and thaws throw down portions of the outer columns. From the vastness of the rock pile at the base of the standing columns it is evident that this process of disintegration has been going on for many centuries. The posts are composed of basalt of great hardness and density, the product of volcanic eruption. Exposed portions of the top of the pile show the scratching of glaciers, yet the pile itself and the surrounding country is covered with a layer of pumice dust, an evidence that the "post-pile" is the product of a volcanic eruption which occurred after the glaciers had long since retreated.

Fossil Plants Twenty Million Years Old

GEOLOGISTS describe what is known as the Denver Basis as a great, low, swampy region (Denver is approximately its center) which existed during an early period of the earth's history when the Rocky Mountains were just pushing their way up out of the primal ocean. This great "basin" was made up of shallow lagoons and low-lying, sandy shores on which grew a rank, tropical vegetation somewhat sim-

A huge pile of basaltic columns which brings to mind Ireland's "Giant's Causeway"

ilar to that of the valley of the Amazon today. Huge palms, fig trees and giant ferns were laced together with a tangle of vines, through which man, had he been on the earth at that time, would surely have found it difficult to pursue or escape from his enemies. And of the latter there would have been many. The country must have fairly swarmed with strange animal life, according to the bones of scores of species of the enormous, half-animal, half-reptile of the Mesozoic Era.

The photograph shows the perfectly preserved leaves and stalks of this swamp growth, which was submerged in the sandy shores of some lagoon. The air having been excluded, the growth was silicified and fossilized. At a glance it resembles the intricate carving in coarse sandstone such as might have been used in some ancient decoration. This formation is placed by geologists as belonging to the Cretaceous Period which is variously estimated to have been from fifteen to twenty millions years ago.

A two hundred ton rock of salt which recently fell into the working chamber of the greatest salt mine in Austria

A Piece of Salt that Weighs Two Hundred Tons

AT the famous salt mines of Wieliczka, eight miles southeast of Cracow, Galacia, which was the scene of bloody fighting between the Russians and the Austrians, there recently fell a huge mass of salt weighing some two hundred tons. The great block evidently became detached from the roof of one of the chambers and came crashing to the ground. In its fall it demolished a portion of a passage and broke down heavy timbered barriers. No one was hurt, however

Perfectly formed leaves and twigs fossilized in the course of twenty million years

These salt mines are famous not so much on account of their size and large output as for the many wonders they contain. Indeed, they are regarded as one of the show places of Europe. They comprise a sort of underground world, with all kinds of chambers, such as ballrooms, restaurants, theatres, churches, chapels and monuments hewn out of the solid rock salt. In these chambers may be seen wonderful chandeliers carved out of the rock salt. There are sixteen subterranean lakes in the mines, on one of which is a boat. It lies some seven hundred feet below the surface of the earth. The aggregate length of the galleries at present accessible is upwards of sixty-five miles and that of mining railways twenty-two miles. The mines have an annual output of no less than sixty-five thousand tons. They are the property of the Austrian government and have now been worked for upwards of a thousand years.

Raising Goldfish by the Acre

Millions of goldfish are raised on this farm. More money can be made out of goldfish than out of grain

Raising goldfish is no lazy man's job. You must wade in and sort out the marketable fish with your bare hands

Photo from life by Dr. R. W. Shufeldt

INTENSIVE goldfish farming is more profitable than cattle-raising, in the opinion of Eugene Catte of Langdon, Kansas. He has ten acres of ponds given over to the raising of the shiny little parlor fish. Millions of goldfish have been reared by Catte since he started in the business years ago, but the demand for goldfish continues to grow.

That fish farming is a paying business when conducted on a wholesale scale is evidenced by the fact that this Kansas farmer has been able to make as much money from his ten acres of goldfish ponds as other farmers from their one hundred and sixty acre farms. In fact, the industry has grown to such proportions that Catte has turned his big grain farm over to his son in order that he himself may devote all of his time to the raising of goldfish.

Years ago Catte started a private fish hatchery on a homestead he had taken up near the foot of the sand hills. He was able to convert some bogs and a spring into a fish pond, where he began raising fish for the market. There soon sprang up such a demand for small fish, however that Catte found it more paying to turn his attention to goldfish. Now his business has grown to such an extent that his hatchery covers thirteen acres and is composed of fifteen ponds, ten of which are devoted to goldfish.

Catte's busy season begins in the autumn. Most of his time is spent in wading about in high rubber boots, sorting out the marketable fish with his bare hands. This is no lazy man's job. Goldfish farming consists in something more than reading the newspaper on the back porch, waiting for the fish to grow.

What Is Hoarfrost?

IN every-day English the word "rime" is synonymous with "hoarfrost" and is applied to the fine white deposit which replaces dew in cold weather. Hoarfrost is sometimes defined as "frozen dew," but it is more often a direct deposit of small ice crystals from the atmosphere, the invisible water vapor turning to ice without passing through the liquid form.

In recent technical literature the term "rime" has a different meaning. It is limited in its application to those striking deposits of rough ice or of feathery crystals which sometimes form on exposed objects surrounded by fog, when the temperature is below freezing. This formation is, in its turn, distinguished from the smooth coating of ice which results from rain in cold weather, and to which the name "glazed frost" is now applied. Heavy deposits of glazed frost often load branches, wires, etc., to the breaking point, and give us the familiar phenomenon of an "ice storm."

Hoarfrost is a powerful but mischievous magician. Above, a beautiful effect created on a tree; on the right, a wire rope

Of all these various frost deposits, true rime perhaps presents the most curious forms, and these reach their fullest development on mountain summits and in the polar regions. Beautiful tufts and fringes of ice form on objects of small diameter, such as twigs and wires, and along the angles of square posts and the like, but not on broad surfaces. The deposit is almost or quite confined to the windward side, and grows against the wind.

At the former meteorological observatory on Ben Nevis these ice feathers were sometimes seen to grow at the rate of two inches an hour. In the winter of 1884-5, according to Mr. R. T. Omond, "during a long continuance of strong southwesterly winds and cold weather a post four inches square grew into a slab of snow some five feet broad and one foot thick in less than a week; the crystalline mass then fell off by its own weight and a new set began to form."

The anemometers and other out-of-door instruments at the observatory were generally so coated with rime in winter as to be useless.

A Curious Tobacco Pipe-Borer

TRAVELERS among the Sioux Indians are very much impressed with the perfect smoothness of the bore in their pipe-stems. Without the use of a tool of any kind, they make a perfect bore in the twigs of ash trees, which they use for musical instruments and for pipes. To accomplish this end, they employ the larva of a butterfly which inhabits the ash tree. The Indians remove the pith for about three inches from the stick they wish bored. Into this cavity, they place one of the larvæ of a brown butterfly, which gradually eats its way down through the pith until the bore is completed. A little heat applied to the wood expedites the work of the larvæ. The Indians consider both the tube made in this way and the larva as sacred as their idols.

Leaping Horses That Are Unafraid

Though horses usually hesitate to jump over obstacles near human beings, the horse of a United States Army lieutenant jumped over a mess table surrounded by soldiers. He showed no hesitation, and did not upset even the bottle of sauce or pitcher of coffee on the table though they were dangerously near the flight of his heels

At right, a feat of horsemanship not without an element of danger to both horse and rider. The illustration below shows "Rabbit," a privately-owned horse of Washington, D. C., hurdling a high-powered racer without making a scratch in its white hood

On the Island of Laysan in Oceania, Thousands of Albatross Live from November to January. The Island Is So Rarely Visited That It Is a Veritable Albatross Paradise. The Birds Are Splendid Flyers and Swimmers, but on Dry Land They Are as Clumsy as Geese. The Spread of Wing of Albatross is Seventeen Feet, and the Length of the Body Four Feet

The Albatross Breeds Between November and December. The Nests Are Mere Holes Dug in the Ground and Lined with Twigs and Grass. The Female Lays Only One Egg. In March the Old Birds Leave the Island. They Return in October and Drive Away Their Own Young—Which Have Grown Up into Strong Fighters in the Meantime

for Fertilizer and Eggs, Products of the Albatross

An English Company Is Exploiting the Island as a Source of Guano Fertilizer. A Ship Lands Periodically and the Eggs of the Albatross Are Gathered in Wheel-Barrows. The Eggs Are Sold in Honolulu, Even Though They Are Not as Fresh as They Might Be

What's the Good of a Hawk?

By Dr. R. W. Shufeldt

OF what use to man is this great army of hawks, harriers, and falcons we see or read about?

There was a time when these "hawks" and their kind were simply regarded as fit subjects for the brush and pen of the professional ornithologist; for the scalpel of the taxidermist, or a legitimate target for every gunner in the land that came across them in the open.

There is a splendid array of falcon-birds in our avifauna, the principal representatives being the Eagles, the Falcons, the Hawks, Kites and Harriers. Besides these, we have two species of Caracaras, as well as the famous Osprey or Fish Hawk. When one includes the latter, with the four different kinds of Eagles recognized by American ornithologists, there are in the United States, all told, no fewer than thirty-two species and twenty-one sub-species of such birds. None of these are as abundant as they were half a century or more ago, or even less time. Indeed, during the autumnal migration of birds southward in the early seventies, in the southern part of Fairfield County in Connecticut, I have seen as many as a thousand or more different kinds of hawks pass overhead in the course of a day; I very much doubt that one now could count, at the same time of the year, over a hundred.

Profile of the Osprey or Fish Hawk which lives entirely upon fish and other water food

The thoughtless farmer argues that hawks of every kind kill domestic poultry, and that he, for one, is for exterminating the entire lot of them. That thousands of chickens, ducks, young turkeys, tame pigeons, guinea-fowls and other denizens of the farmer's yard, have been, in time, destroyed by hawks, there can be no question; but even so, our investigation of such a serious matter should not rest upon a snap judgment, and lead us to condemn the entire tribe on that account.

In the first place, some hawks, as the Fish Hawk, live entirely upon fish, and never attack or destroy any kind of fowl or mammal, although it has the strength to kill a full-grown gobbler, were it to try to do so. The illustration here given is the reproduction of a photograph I made of a bird not quite full grown, which was in my possession for several days; I also made the other photographs for this article from living specimens of hawks in my keeping at different times. In so far as man's interests are concerned, the Fish Hawk or Osprey is entirely harmless.

All those hawks which we call Kites do not, as a rule, attack birds or quadrupeds of any kind, and *never* domestic poultry. They destroy, however, in the course of a year, millions of noxious insects and no end of vermin, which prey

upon the crops of the agriculturist. Still other species of hawks, as the Duck Hawk, prey entirely upon feathered game, and never come near the barnyard. Birds of that class do no more than we do ourselves—hunt ducks for food.

That a number of species of hawks do constantly prey upon both the old and young of various kind of domestic fowls, there is no question; moreover, they feed upon a large number of them in the course of a year. Still, no individual poultry-raiser or farmer loses a sufficient number of his fowls annually, through the attacks of hawks, either to impoverish him or so far embitter him as to cause him to be the enemy of every hawk of every species in the country. To follow such a policy is an extremely grave error; it would be like exterminating all snakes and owls for the reason that a *few* snakes are venomous, and the *larger* owls occasionally capture a domestic fowl. If we consider *all* the snakes and *all* the owls as a group, they save from damage and destruction farm products to the extent of many millions of dollars annually. The pity is that they are so constantly preyed-upon that they cannot accomplish results to be appreciated by us.

The Broad-Wing Hawk which preys upon mice

A very young Sparrow Hawk in its fledgeling covering

Full-grown Sparrow Hawk—one of the farmer's feathered friends

Wolves of the Sea that Abound in Cuban Waters

FACTS appear incontestably that sharks, and big ones, abound in Cuban waters; that thousands of swimmers are never attacked; and that there are perfectly authentic instances of people being maimed or killed by them.

The Antillean shark is less dangerous than some Australian and South Pacific species. In clear water of fifteen or twenty feet depth he is timid. Near a boat anchored where the bottom can be seen from the surface, as in those waters it commonly can be at the depth named, the bather is safe. In deeper water there is risk. If there is blood in the water from a wounded man or fish, the swimmer's peril is great. Indifferent, lazy creatures, of a low order of intelligence, sharks are instantly frenzied by the presence of blood, and will attack anything that moves.

More than the sharks, the Barrera cruisers fear, when inclined to a morning plunge, the picoua, a big and aggressive fellow with a protruding jaw fitted with long, sharp teeth. Lying motionless near the bottom in rocky retreats about the offshore reefs, he darts at his prey with remarkable swiftness. His sinister appearance has given him an evil reputation.

Balanced Rock, in the Garden of the Gods, Is So Perfectly Poised That Formerly Two People Could Sway It. Now It Is Cemented Firmly in Place

Rocking Stones and Their Romantic Story

IN some of the accompanying photographs are to be seen three different kinds of rocks, perched by Nature one on top of another. How could they have been placed in such positions? They weigh many tons.

Millions of years before the coming of the first man on the earth, the two top detached boulders were gently placed in their present resting places by the hand of a veritable giant—the North American glacier. During the Great Ice Age the whole of the northern portion of the United States was covered hundreds of feet deep with glacial ice. A glacier is snow, which, by melting and intense packing, is formed into solid ice banks. But the glacier is a constantly moving ice mass. It travels slowly but with enormous grinding and carrying power, down the slopes and valleys.

A mass of ice several hundred feet thick, constantly replenished at its source, and sliding down a mountain slope with a weight of many tons to the square foot must have been well-nigh irresistible. That such was the case is illustrated by the many enormous boulders which were picked up from their original moorings by the huge glaciers of the Ice Age and transported many miles before they were deposited by the melting of the ice.

Without this now well established explanation of glacial transportation it would be impossible to account for the queer positions in which boulders are often found as well as for the intermingling of entirely different kinds of rocks in the same place.

In one of the photographs the upper boulder is a rock about five by eight by eight feet, of coarse Massachusetts granite. It is securely perched on a different kind of rock of nearly the same size—a rock known as a gneiss. Both are resting on a granite ledge, but of a different texture from that of the upper granite rock. Even assuming that the two granite rocks were alike, without knowledge of glacial action, it would be difficult to account for the presence of the middle boulder weighing at least ten tons.

Nowhere in the United States are the evidences of the tremendous force of the great glaciers of the Ice Age more striking than in the Sierra Nevada of California. Rugged V-shaped mountain gorges have been scoured and smoothed out into broad U-shaped valleys by the great descending ice masses. The dirt and rocks have been spread about on the plains below or at the mouths of the canyons, while the glacial scratches and furrows can be plainly seen on the remaining rocks in

The Upper Boulder Is of Massachusetts Granite. It Is Resting on a Rock of Gneiss, and Both are Perched on a Granite Ledge of Different Texture From That of the Upper Granite Rock

At Left Below, A Rock Transported and Deposited by Huge Glaciers from the Sierra Nevada. This Rock will Outlast Its Base Many Thousand Years

Below, An Erratic Rock Fragment Resting on a Big Base, Brought to Its Present Position by an Agency Powerful Enough to Transport It Over Irregularities in Land Surface

Above, A Perched Granite Boulder Left on a Sandstone Base by a Glacier Which Melted on a Slope of the Famous Yosemite Valley, California. The Sandstone Pedestal Is Greatly Weathered and in a Hundred Thousand Years, Perhaps, It Will Wear Away and Precipitate the Heavy Boulder Into the Canyon Below

At Right, The Large Boulder Which Serves as the Base Is Rapidly Wasting Away While the Smaller Boulder on Top of It—Weighing a Ton or so—Shows No Signs of Deterioration, Although It Has Probably Rested in This Position For the Better Part of a Thousand Centuries or More

The photograph with the man standing beside a rock shows a perched granite boulder left on a sandstone base by a glacier which melted on a slope of the famous Yosemite Valley, California, a vast gash in the Sierra Nevada, now believed to have been largely cut out by glacial action. Since the boulder was so deposited it has changed but little. The sandstone pedestal, however, is greatly weathered and in the natural course of events, in a few hundred or a thousand years perhaps, will further disintegrate. Then the boulder will be precipitated down the steep slope of the gorge into the canyon below.

A Typical Crevasse Caused by the Earthquake Which Demolished San Francisco

What are now the beautiful Tuolumne Meadows of California were formed by billions of tons of rock and soil, including many great boulders as large as houses, which were transported by glaciers from the Sierra Nevada. Most of this material has been formed into soil and grass, trees and running streams all to make a beautiful natural park. A few great granite boulders still remain to be a witness to the might of a glacier which melted away long ago.

One of the pictures shows a large boulder which is beginning to disintegrate, while the smaller boulder—weighing perhaps a ton—is perched on top of it, having rested in this position for probably the better part of a thousand centuries. Another of the photographs shows a large erratic boulder resting on a rock outcrop in Mono Valley, California. Undoubtedly it was transported to this point from the nearby Sierra at a time when the ice streams flowed strongly down the eastern slope of this range to levels much lower than those reached by the feeble glacier remnants now existing near the summits of the range. This boulder could have been brought to its present position only by some agency not now present and one that would disregard topography, riding over irregularities in land surface and leaving erratic rock fragments perched in positions to which water could not transport them.

The famous Balanced, or Rocking, Stone of the Garden of the Gods in Colorado was deposited in a similar way by the glaciers of the Rocky Mountains. It is a stone of very large dimensions, and so exactly does it balance that until lately it could be swayed easily. The continual rocking to which it was subjected by thousands of tourists ground away the base to such an extent that to preserve it as a curiosity it was cemented in place.

One of the Pranks of the San Francisco Earthquake

ABOVE is one of the crevasses caused by the earthquake which almost destroyed San Francisco. Earthquakes are always terrifying events, but they are only excessively destructive of life and property in case the territory affected is thickly populated and highly improved. At this uninhabited point the great earthquake of 1906 resulted only in a natural curiosity, but imagine this rift occurring beneath the business block of a prosperous town! In another place a quarter of a mile of wagon road was bodily removed ten or twelve feet from the rest of the road

Insect Grotesques Which Assume Frightful

Above, a good instance of the grotesqueness of many of the living insects which make up the Membracidae, of, which more than eight hundred species have been found

At right, the well-known Brazilian "thorn-bug," one of the insects, which looks exactly like a big thorn when it is at rest. Its shell is hard and the protruding points are sharp

Another quaint Membracid. The use, if any, of the strange extension of the prothorax is unknown. It is part of the "back-plate" that Nature has worked upon to produce the varied and wonderful forms for which these insects are so remarkable

Above, a number of seed-like Membracidae from tropical South America. They are probably overlooked by all but the most astute insect-eating birds in search of a meal

At left, an extraordinary insect with a huge, helmet-like expansion of the prothorax. This is so large in some insects that they are completely covered by it

Below, a strange looking insect which, when alive, looks as if it were being attacked by a spider. This is really the insect's armor plate

At right: The apparent body and formidable sting of this insect are a mere pretense, being only a horny outgrowth from the thorax

What Wind and Rain Can Do

How Nature's Chisels Work Through Millions of Years

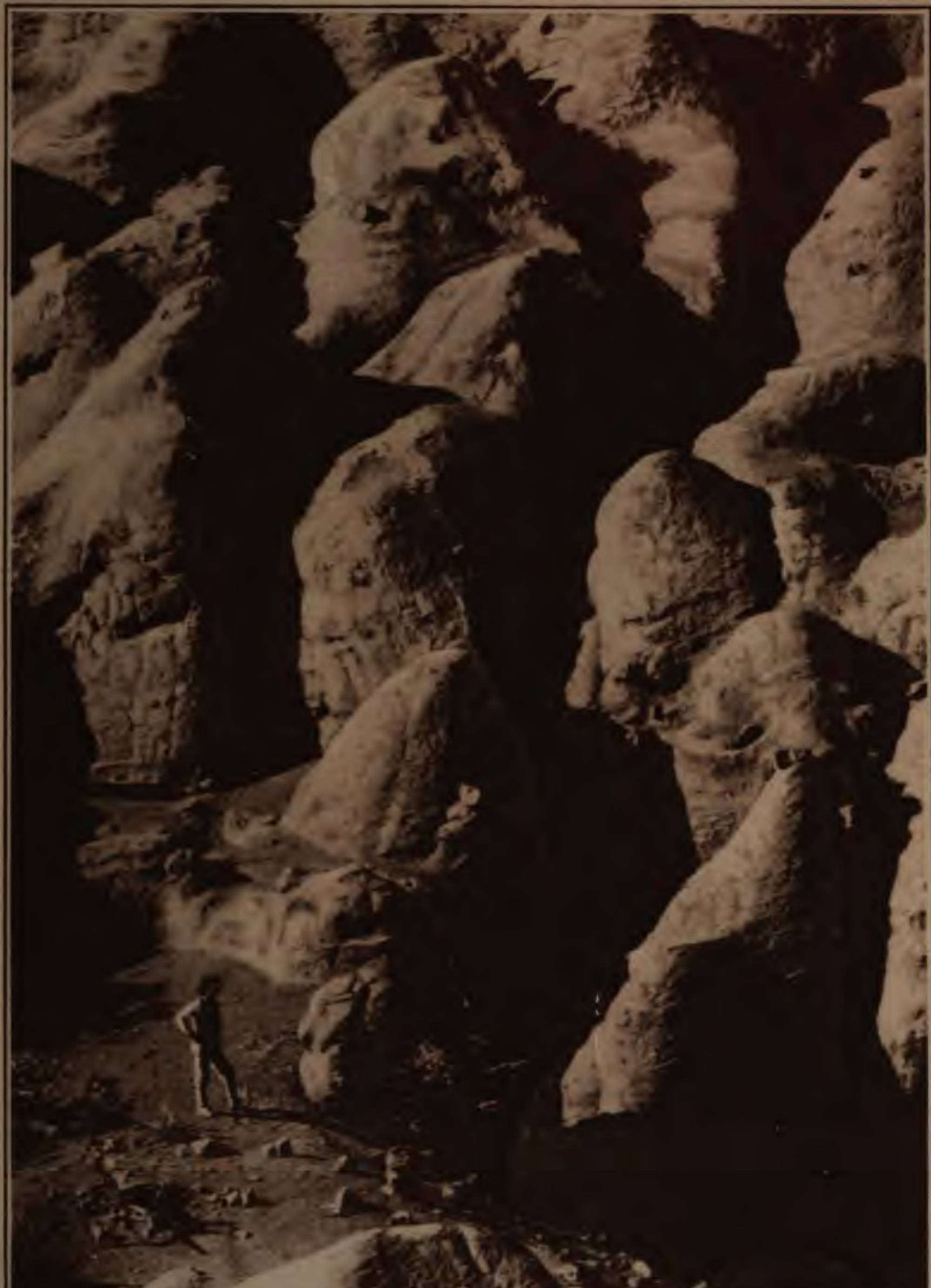
ON the sloping "shores" of the great salt-incrusted playa at the bottom of Death Valley, California, which is the bed of an ancient lake, there is a large volcanic rock which, it is stated, has appeared to grow out of the ground several feet within the memory of the pioneers. When first observed, this was simply a large irregularly-shaped rock resting on the ground. Since then it appears to have been pushed upward. It is supported on a fragile, wedge-shaped neck not over a couple of feet broad. The apparent instability of the thin neck with its top-heavy burden is accentuated by a good-sized hole in its middle, so that in traveling the trail which passes directly under the rock, the tenderfoot is apt to feel relieved when the formation has been left behind.

Contrary to supposition, there has been no growth or uplift of this rock. The earth at its base has been washed and blown away by the winds and the cloud-bursts, which, on rare occasions *occur* even in this intensely desert region, sweeping everything before their great volume of water.

On the opposite page is pictured another product of wind and rain, probably one of the most singular collections of rock figures in existence. Acres and acres in extent, from a distance they resemble, as much as anything, a vast family or colony of gigantic prairie dogs sitting on their haunches, and covering the entire slopes of Red Mountain, Arizona. The figure of the man in the left center of the photograph indicates the size of these "prairie dogs."

Mushroom Rock—one of Death Valley's curiosities

This mountain is a cinder cone of the San Francisco plateau, and the village of rock forms has been caused by the cutting and sculpturing of the soft lava by the wind and rain. The cinder cone of a volcano is the last upheaval, the result of the dying gasp of eruption. So stupendous, however, has been the dynamic energy attending many of the earlier volcanic disturbances of the West that there are cinder cones several thousand feet in height.



Sculptured by the Elements

Many acres are covered with these giant ninepins of soft lava. Of colossal size, as shown in contrast to the human figure, they resemble, from a distance, a vast colony of prairie dogs sitting on their haunches

When Nature Plays the Architect of Bridges

The Nonnezoshe, or Rainbow arch, shown above, has been carved by the elements from the brick-red sandstone of southeastern Utah. The Navajo Indians called it the Sun-Path and beneath it are ruins of an ancient altar doubtless built by superstitious cliff-dwellers

Her Tools Are the Elements and World-Old Rock

Notwithstanding the fact that the Owachomo Bridge in southwestern Utah, shown on the right, is called the "Little Bridge," it is one hundred and six feet high and nearly two hundred feet wide

The natural bridge of Santa Cruz, California, shown in the picture extending across both pages below, arches a perfect causeway, which has been formed by the inrush and outwash of waves during many centuries

A Magician Among the Fishes

IT IS doubtless true that there are no mermaids in the sea and no Neptune with crown and flowing locks, but the species of life that do exist there are in many ways equally as interesting as the mythological folk. Take the little puffer fish, for example, which has attracted the attention of scientists from earliest times on account of its shrewd habit of defending itself by inflation. The moment it scents danger in the form of a larger fish, searching for a dinner, it instantly distends itself with water until it becomes almost spherical in shape, so that no ordinary fish could swallow it. Director H. C. Townsend of the New York Aquarium, placed a few good-sized scup, or porgies, in a tank which contained a dozen young puffers about two inches in length, which the hungry scup attacked at once. Instantly the baby puffers inflated themselves and became almost globular in form, so that the larger fish were unable to do more than knock them about *like toy balloons* too large to be swallowed, and on which they could get no hold whatever.

Above: The puffer in normal shape. There are numerous species, varying in size

Left: When inflated the puffers can be knocked about on the beach like balls

A candle suspended from a wire shines through the stretched skin as through thin oiled paper making a bizarre lantern

The puffers are of many species, many of them reaching a length of about two feet, most of the larger kinds being found only in the large rivers of the tropics. When caught in nets and dragged ashore they inflate themselves with air just as with water when in the sea, making a slight sucking sound until their skins are as tight as drums. They remain inflated until thrown back into the water and can be knocked about on the beach like rubber balls without a particle of air escaping. Even when thrown back into the water they may float upside down for a time before assuming their normal shape.

A valve in the throat is the means by which this choice, edible fish is changed into an unmanageable balloon and back again when its fright is over.

The valve seems to be controlled entirely by the volition of the fish, unless the fright which the fish experiences upon

sighting danger causes the valve to open spasmodically, thus allowing an inrush of water or air. Sometimes the puffers die while still inflated, and they remain in that shape, being often driven ashore by the wind and dried on the beach by the sun.

The Japanese make lanterns of them when they find them in that condition. They cut out the back and suspend a candle from a wire into the fish body, as shown in one of the accompanying illustrations which are published by courtesy of the New York Zoological Society. The light shows as brightly through the stretched skin as through a piece of oiled paper.

Some of the puffers are covered with spines which become rigidly erect when the skin is inflated. This species is also known as the sea porcupine. All the puffers have hard, strong beaks like parrots, which are well adapted for crushing the shells of the crabs and mollusks upon which they live. At certain times of the year, probably during the months that contain no "R," they are considered poisonous in the tropics, so much so that the gall of a Japanese species was formerly used to poison arrows.

The appearance of the yareta from a distance is that of a huge recumbent sheep

A fragment of yareta showing the sponge-like construction of the interior in which resinous substance is secreted

The Strange Vegetable of Peru That Resembles a Sheep

A CURIOUS plant growing in Peru is known to the native as "Yareta" or "vegetable sheep." It grows abundantly among rocks at high altitudes along the Andes of Bolivia and Peru, where it constitutes a conspicuous feature in the landscape because of its peculiar manner of developing the so-called "polster," or cushion formation.

The "yareta" forms hillocks or small mounds often three feet high and sometimes several feet in diameter. Moreover, the entire mound is made up of a single plant, not of a colony of individuals, and it attains this enormous size and extreme compactness by a process of repeated branching, so that the ultimate branches are closely crowded and the outer surface is continuous.

The flowers of the "yareta" are very thin, only about one-eighth of an inch long, and are borne in small clusters near the tips of the branches. The fruit resembles a miniature caraway seed. The natives use the plant as fuel.

A Tree Like the Rock Which Moses Smote with his Rod

Photo Janet M. Cummings

The Traveler's Tree, so called because when its stem is cut a quantity of pure, cold water *spurts out*, grows throughout the West Indies. Its leaves resemble those of the banana tree

One Tree Grows Through Another

IN a West Virginia forest nature has played an unusual prank upon two trees. One of them is a maple and the other an oak. Close inspection reveals the interesting fact that the oak tree has beyond doubt grown up through the maple. The oak being the more rugged of the two trees is causing the maple where its bifurcated trunk joins, a few feet above the ground, to split.

An oak tree growing through a maple

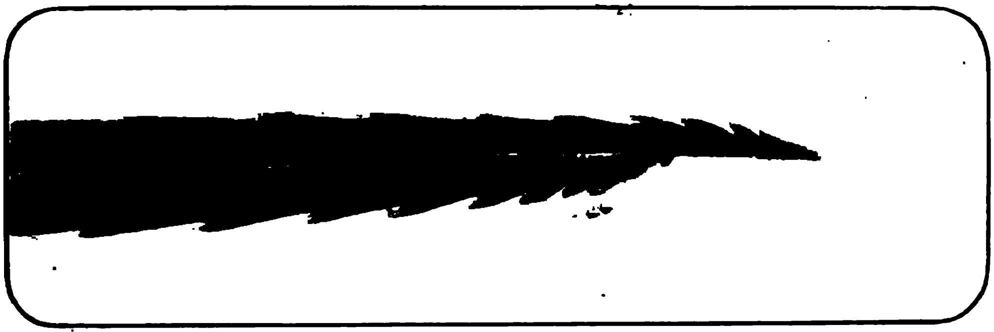
Asleep On the Sleepers

WHEN the first railways were built in China it was necessary, first to force the coolies to work upon them at the point of the bayonet, and later, to protect these coolies by force of arms from the outraged inhabitants of the countryside through which the railways ran. This feeling passed rapidly, however, as the Chinaman's philosophical disposition asserted itself. The accompanying photograph illustrates graphically the way in which the Celestial has taken the railway. The soporific individuals are section hands on the Shanghai-Nanking Railway, and because the little wooden pillows on which they and their ancestors have been resting their heads for a good many thousands of years were almost exactly similar—both in height, cross-section and hardness—to the eighty-pound "T" along which they were working, they were not long in adapting the convenient metals to the same purpose. There is one swift express which speeds over the straight and well-ballasted track between Shanghai and Nanking at the rate of sixty miles an hour, and in the first days that the "noonday sleep" habit became popular it was no uncommon thing to have two or three decapitated coolies reported at headquarters every evening. This finally became so troublesome that orders were sent out prohibiting the practice absolutely, and holding the section bosses responsible for the men in their gangs, but even to this day, casualties from sleeping on the track still occur.

The Chinaman's pillow is a hard wooden bench, the size and shape of rails. So why shouldn't the coolies use these nice pillows the railroad laid down

A Fish That Builds a Nest Like a Bird

The Stickleback is one of the most interesting members of the finny tribe. It constructs a home for its prospective mate and then mounts guard over it until the mate comes along. The home is built from sea-weed, twigs and aquatic plants which are ingeniously woven together. There are two entrances to the home, which are never left unguarded by the master of the house until the lady of his choice signifies her willingness to enter



The bee's stinging apparatus as shown up by the microscope. It consists of a sheath within which move two barbed lancets. These form a hollow tube for the poison

The Honeybee's Infernal Machine

IN proportion to its size, the sting of the honeybee is probably the most effective infernal machine in existence. The stinging apparatus is smaller than that of a rattlesnake, yet a single sting has been known to kill a man. When we realize that it is almost invisible, and consider what it can do, we cannot fail to be astounded. It seems the very quintessence of devilishness.

The honeybee's sting is complicated—so complicated that many words and much ink have been used in discussing its construction and use. It is generally conceded that the sting consists of a shaft of three parts, the principal one being a sheath within which move two barbed lancets. Like the barbs of a fish-hook, the lancets are not easily extracted from the flesh into which they have been driven. The sheath and the lancets combined form a hollow tube through which the poison flows from the poison-sac. Two hairy, soft projections, evidently very sensitive, inform the bee when she is in contact with a stingable object.

A snake's fangs are harmless when removed from the snake. Not so the bee's sting. Man, with all his ingenuity, has not yet devised a machine or a thrower of poison gas that will continue to act after the soldier is dead, but nature has done something like it in the honeybee.

At one time it was supposed that the poison that accompanies the sting is formic acid. That is now doubted, although the material has an acid reaction. It is a curious fact that there are other poison glands in the bee that are alkaline. A well-known investigator asserts that the secretion of both sets of glands must be mixed to be fully effective. The secretions enter the barbs. Here the two are mixed, later to be forced out of the channel formed by the sheath and lancets and through certain openings in the lancets. Both the channel in question and the openings were formerly supposed to be merely passages for the poison. It has been shown by a skilful investigator that the channels in the lancets are not connected with the poison duct, and that they are smelling organs, used probably in gathering the nectar for the making of honey.

There is a long list of remedies for the honeybee's sting, all of them worthless. Rubbing or even touching the injured spot does positive harm, because the friction or the pressure forces the poison into the circulation and may intensify pain which would otherwise be only trifling. A well-known authority says, "There is no remedy in the world like letting an ordinary sting alone and going on with the work without even thinking about it."

At times, with no apparent provocation, honeybees will sting a horse or a cow to death within a few minutes; at others they may be thrown around and handled roughly with no more danger than if they were flies. I have shaken the contents of a hive over the bare arms and necks of young ladies without the slightest injury to any one. Again, one may only walk by a hive and be stung.

ın outfit for photographing animals from the bow of the boat. A wooden revolving camera ed, large enough to carry two cameras, is secured to a ball-bearing support which is rigid, bsolutely noiseless and enables the camera to be swung through an angle of one hundred and ighty degrees. When the lantern shines on the animal the flash-powder may be fired, proided the distance is correct. If desired, one lamp may be fired after the other successively, show the animal in different positions. This requires two firing lines and two cameras

Wild Animals That Photograph Themselves

PHOTOGRAPHING by flashlight is one of the more recent advancements in the field of picture-taking which has helped to secure for photography a permanent place among the arts. Paul J. Rainey, the explorer and hunter of wild animals, proved several years ago at the first exhibition of his wild animal flashlight pictures taken in Africa, that this class of photography offered a virgin field to the manufacturer of apparatus and to the man behind the camera. Soon after this there was an awakened interest in animal film shooting in preference to gun or trapshooting.

At the present time photographic flashlight apparatus has been developed to a point where guesswork is eliminated and where it is possible to photograph any object in motion. To do this it is necessary for the camera to catch the object in motion just at the instant when the flash powder is giving forth its brightest light. This requirement calls for a high-speed shutter to stop the motion on the plate of the object being photographed. With a flashlamp recently perfected by William Nesbit the shutter is automatically snapped at exactly the moment when the light from the flash powder is most intense. His apparatus has been widely used to take flashlights of wild animals in their native haunts and has given uniformly good results.

When flash powder is ignited it does not burn up or explode instantly, as might be supposed. It burns more and more brightly until it reaches its point of greatest brightness, from which point on it dies down until it goes out. This whole operation takes at the most one fifth of a second. However, good pictures will be obtained only if the camera is snapped during this fifth of a second, when the flash powder burns the brightest.

On the other hand, this point can never be definitely determined before taking the picture. It changes for different powders and also varies for the same powder, since the powder may become slightly damp and will not burn in the same way. It is evident, then, that to snap the camera at precisely the right moment is not so easy as it might appear.

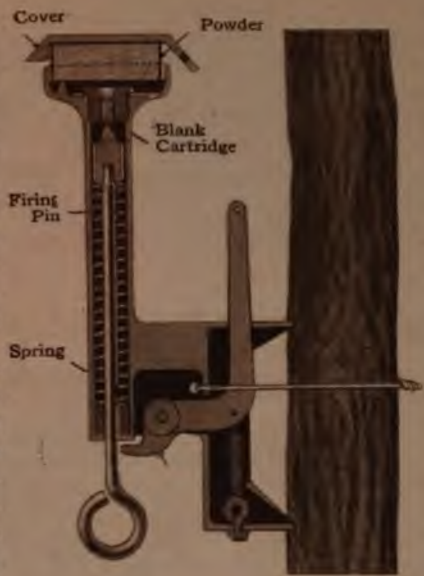
The flashlamp devised by Mr. Nesbit consists of an aluminum container to hold the flash powder, a cover for this container, a mechanism to fire the powder, and an attachment which will automatically snap the shutter of the camera at the moment when the flash powder is burning brightest. The unit is waterproof, and so compact that it can be readily attached to a tree or other convenient support.

The flash powder is placed in a box made waterproof by a coat of paraffin and is then placed in the space provided for it in the flashlamp. The powder is fired either by a blank cartridge or by an electric spark furnished by a dry battery. A firing-pin, controlled by a spring and a trigger, similar to those used in a rifle or revolver, sets off the cartridge.

When taking a flashlight of an animal, a wire is attached to the trigger and then tied to bait of some sort. The animal is attracted by the bait, and if it touches it, the wire is pulled, which, in turn,

pulls the trigger, releases the firing-pin and ignites the powder by exploding the blank cartridge. When the powder is to be ignited electrically, a wire is stretched from a switch to the bait. Once the bait is touched a circuit is closed and an electric spark sets off the powder.

The shutter on the camera designed by Mr. Nesbit is operated by means of the cover placed over the container holding the powder. This cover is attached to a chain



be found. The cover is so arranged that it cannot be blown off until the powder is burning with its greatest brightness.

When the wire to the bait is pulled, the powder is ignited and commences to burn. For a small fraction of a second the cover remains in place while the powder burns. Then, when the powder is burning with greatest vigor and is giving off its brightest light, the cover is blown off and the shutter of the camera is snapped.

Below, the animal attracted to the bait, which is attached to a trigger which releases the firing-pin

The wiring arrangement, showing the flash occurring at the very instant the bait is touched by the animal

which is fastened to a tree or post supporting the lamp. This is to prevent the explosion of the powder from blowing the cover so far away that it cannot

Sometimes two sets of cameras and flash-lamps are used to give two pictures of the same animal in different positions, before and after his fright.

A Slab of Sandstone Seventy-Five Million Years Old

A SLAB of sandstone stands on edge in the bed of an Ohio stream. It has peculiar markings made in times past by ripples when the stone was soft sand. The layer of rock from which this slab was broken extends far back into the bank of the stream, and comes to light again in a quarry a mile distant. In fact when the ripple marks were formed it was the soft sand of an ocean shore.

In short the pictured slab is a piece of what geologists call Berea sandstone, formed from ancient sediments at least seventy-five million years ago. To-day the Berea sandstone beds are of importance because great quantities of oil and gas are found in them.

A slab of sand-rippled Berea sandstone of practically incalculable age

A Curious Egg Shaped Like a Dumb-Bell

THE freak egg shown in the picture on the right was laid by an ordinary Leghorn hen. When first laid it was a perfect dumb-bell in shape, having two yolks, one on each end, connected by a sac enclosing the albuminous portion.

The freak egg compared in size with a normal egg laid by the very same hen

The inner bone formation of a whale's ear picked up by a Scandinavian fisherman

Would You Recognize the Ear-Bone of a Whale If You Saw One?

HERE is an actual photograph of a natural object. Does it remind you of a human face, exaggerated as in a cartoonist's drawing?

But it is only one of those freaky resemblances so often seen in natural objects or formations.

The photograph represents one of the ear-bones of a whale, an object about three times the size of a hen's egg. A whale has a most complicated ear mechanism, composed of several bones and ossicles of different sizes, interlocked by curious angles and facets. Sometimes one of these bones is cast up on the beach. The photograph represents such an ear-bone picked up by a fisherman on some sandy beach on the Scandinavian peninsula; and by a curious coincident it looks most like the type of face sometimes seen among the lower classes of Scandinavians.

Roots instead of branches were grafted to this pear tree, and with the fresh life brought to it by the healthy young suckers, the old tree returned to its previous record crops

Giving a Pear Tree New Roots

THE startling operations performed upon human bodies by advanced surgical methods find their counterpart in tree surgery. How a pear tree was supplied with new roots after its own had been destroyed, is an example. The disease which required the drastic treatment of removing the roots of a well-grown tree is "pear blight," which can be eradicated only by cutting away all affected parts. So dangerous is this tree disease that even the knife which is used in cutting away the bark, wood or roots must be sterilized after each use, in order to prevent the contagion from spreading to sound parts of the tree.

Should the disease attack the roots, as in the instance shown in the photograph, it is necessary to supply nourishment to the tree by grafting to the trunk a number of healthy young "suckers." These are well rooted and are set into the ground about the diseased tree, while the upper ends are grafted upon the trunk, so as to carry the sap from the ground by healthy channels.

Fly Impaled by Spear of Grass

ONE of the most interesting accidents that has ever come to the attention of zoologists is shown in the accompanying illustration. While lying in the tall grass near Fire Island, N Y., waiting for game birds, Dr. A. L. Goodman, a New York physician, saw a fly perching upon a spear of grass near him, and entirely unafraid of the hunter, for it never moved. After watching the fly for nearly half an hour, Dr. Goodman's curiosity was so aroused that he got up and, upon examining the insect, found that the sharp point of the grass had pierced the fly's frail body.

The insect had evidently been flying against the wind, when a sudden gust blew it down against the blade of grass, which had swayed with the wind. Dr. Lutz, of the American Museum of Natural History, says that in the fifteen years that he has collected specimens he has never seen a similar accident, nor has he ever read of such an occurrence.

Hammering Spine to Cure Sick Heart

AS a remedy for enlargement of the heart, Dr. Meyer Solis-Cohen hammers the spine with a rubber-tipped hammer. The tapping should be done on the protruding vertebra in the spine at the bottom of the neck, a little above the shoulderblade. It immediately livens the valves of the heart.

Army Pistol Shoots Colors

A DECIDED novelty in the way of pistols has been perfected for use by the United States Signal Corps for the purpose of communicating at night. In appearance, the pistol resembles the old-fashioned dueling pistol except that it is lighter and smaller. Cartridges firing spurts of flame of various hues are used for ammunition, the color of the flame carrying a definite message to the distant lookout.

A One-Pound Diamond

THE great diamond mines of the Transvaal have been revealing their age-long secrets for many generations, but the greatest surprise of all came on the twenty-fifth of January, 1905, when

One and one-third pounds was the weight of the famous Cullinan Diamond. It was cut into two large gems and over a hundred smaller brilliants

the Cullinan stone, afterward named *Star of Africa* by George V, was discovered. When the excited owners placed the colossal gem on the scales they found it weighed 621.2 grams, about one and one-third pounds. It was more than three times the size of any diamond ever found before or since, weighing 3,025¾ carats, and of the finest quality.

King Edward VII was presented with the stone on his birthday in 1907. Later it was placed in the hands of the famous Amsterdam firm of I. J. Asscher and Company who cut it into two large stones and over a hundred smaller ones. The larger jewel has the exceptional number of seventy-four facets being a drop brilliant of 516½ carats. It ornaments the royal scepter of England. The smaller stone is a square brilliant of 309$^{3}/_{16}$ carats and is the central figure of the English crown.

Only six months were required for cutting the splendid stone, advantage being taken of the planes of cleavage.

An army pistol which shoots colored light

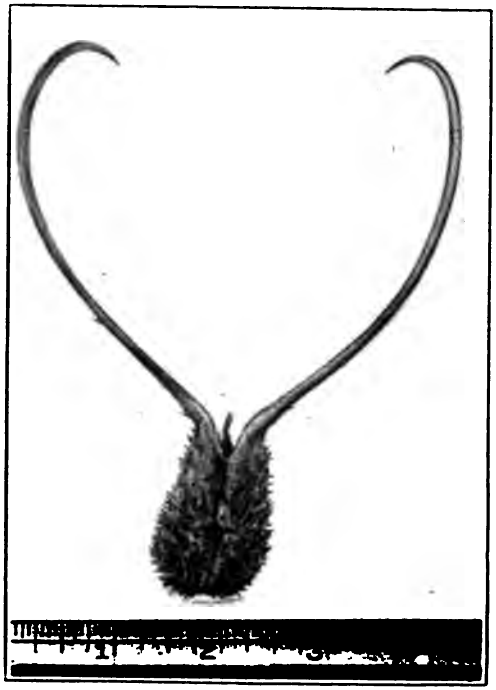
Disinfecting School Pencils

IT has long been recognized that the school pencil is a fruitful source of disease. The pencil points are usually given a bath by the child's placing it in his mouth to soften the lead. Then the pencil is passed on to another child, who does the same, thereby spreading all kinds of communicable diseases. The pencil is disinfected by a new system, through the action of formaldehyde gas upon the bacteria.

The lead-pencil of every child is a germ-carrier. Disinfect the pencil with formaldehyde gas, as shown by the picture in the circle, and the spread of disease in schools will be reduced

A Fiendish Plant Which Thrives on Cattle

A PLANT grows in Persia, which kills by burying itself within an animal's nostrils or sides, the seeds there germinating and imbibing the moisture



A plant which fastens its claws into the nose or sides of cattle, kills them and feeds upon them

from the decaying body. No rain falls on the mountain plateaus of Persia during the whole summer. Vegetation is luxurious in the spring, when water in abundance runs down to the plains from the snow-covered mountain-chains and ridges. A merciless sun, and a dry desert atmosphere soon evaporate what moisture is not carefully stored by artificial means, and all plant life withers and dies, except desert thorns and some species of thistles.

During the spring the fat-tailed sheep and the camels enormously increase the fatty deposit in tail and hump. In two months' time bees store up honey enough for the rest of the year. All nature seems to labor overtime.

When the spring luxuriance of verdure is passing, our fiendish plant begins its deadly work. The fully developed seed pods, hidden under the withering foliage of brown and yellow leaves, fasten their tiger-like claws in the nostrils of a grazing camel, a wild ass, an antelope or a sheep; the animal tries to rid itself of the sharp prongs by rubbing, but the more it rubs the deeper it forces the claw-like tentacles into its tender, tortured skin. In many cases inflammation of the entire throat follows and the poor animal, unable to eat or drink, succumbs. That appears to have been the object of this fiendish plant, for it seems that only in the rich fertilizer of a decaying victim can it find enough nourishment for numerous offspring, which sprout from the hundreds of black seeds contained in its great, belly-like capsule. This is what the drivers of caravans say, and they hold the plant in fearsome awe, giving it many a bad name in their native tongue, such as "devil's flower," the "killer," and the like. The herds of breeding camels are left on the grazing grounds in a semi-wild condition, and wander over many miles to find sustenance.

With a wheel on the front, a canoe can be handled easily by a woman or child

A Wheel-barrow for Canoes

A CANOE-BARROW, invented by a Philadelphia man, makes the transportation of a canoe on land an easy matter. Even a woman can take a canoe down to the water with the barrow. A wheel is attached to a simple metal frame that engages the gunwales and bang-plate of the canoe at one end. It may be attached to an empty or loaded canoe while resting in its natural position on the ground.

The Great Hoodoo Temple

In the Hoodoo Basin of Western Wyoming are curious formations which resemble Punch and Judy heads, grim savages, simpering old maids, monkeys, rabbits, birds and animals in every grotesque and exaggerated shape imaginable, and in every possible position. There are fifty different shapes of heads; over forty different animal and human faces have been counted, and inspiration for innumerable cartoonists may be found there. The rock out of which the hoodoos have been carved by Dame Nature is what is known as volcanic breccia

Rocks Composed of Diatom Earth Which Float

A NUMBER of rocks are so light that they float on water. Most of them consist of diatom earth, which is a soft earthy material like chalk, but differs from it in being composed chiefly of silica-containing plants mixed with the remains of submerged organic growths, or diatoms. Diatoms flourish in the surface water of parts of the ocean, especially in the South Atlantic, where they are so abundant as to becloud it and where they serve as food for whales. Their remains sink to the bottom and form great accumulations of diatom ooze.

The Colorado River after one of its overflows when the water has receded and the western sunlight has baked the bed

Diatom earth is found in many parts of the world, and is extensively used for polishing. It has been used also as an absorbent in the manufacture of explosives, and as a packing about steam boilers. The "silver white" of commerce is diatom earth. In the United States it occurs at many localities, of which two

On the left is a piece of rhyolitic pumice and on the right a piece of hydrocarbon

may be mentioned. Near Richmond, Virginia, it forms a bed thirty feet thick and one hundred miles in extent; and near Monterey, California, there is a bed of it fifty feet in thickness, but of unknown extent.

When samples of it are subjected to a water bath for hours they seem not to absorb the water. To attempt to "waterlog" a piece of pumice is foolhardy.

A Mud Mosaic in the Wake of the Treacherous Colorado

WHEN the great Colorado River goes on a rampage and overflows its banks it deposits vast quantities of mud and sediment. In this way it has built up the enormous rich Colorado delta in Arizona and Southern California, cutting out, through the countless ages, the huge gorge of the Grand Canyon, in many places a mile deep through the rock. The photograph shows what happens to the Colorado River clay, upon the recession of the waters. Drying under the intensely hot sun, which normally reaches one hundred and fifteen to one hundred and twenty degrees in the shade, and cracking into innumerable irregular blocks, it forms a vast natural mosaic. In some places where the water has stood over a flat, this mosaic extends as far as the eye can distinguish.

The Colorado delta is intensely arid in character, only a few clumps of salt bushes being able to subsist. Where it has been irrigated the yields are enormous. The fertility of the soil is almost inexhaustible. The complete harnessing of the Colorado and the utilization of its tremendous flood-flow constitute one of the really big reclamation engineering problems of the day.

This tree was probably pinned down beneath a piece of heavy timber or fallen tree-trunk when it was a mere sapling

At right, a branch of an old sugar-maple has been incorporated in the body of an adjoining tree about fifty years younger

Freak Trees. How Did They Happen?

TO the person who is not versed in forest lore the grotesquely bent tree trunks that are to be found in almost all woods are mystifying and wonder is often aroused as to the cause. Foresters will tell questioners that in the case of trees in mountainous country and other sections where the snowfall is heavy, the weight of snow is responsible in most instances for the queer twists they assume. When a tree is young the weight of snow that falls on its branches often bends the trunk over until it is flattened to the ground. Sometimes it is buried under six or eight feet of snow and held in that position so long that when warm weather comes the tree fails to spring back into it normal position. The summer sun causes the tip of the young tree to turn upward and if it manages to withstand the weight of the snow of the next winter, that portion of the tree will, as a general rule, continue to grow in a normal way. "Hair-pin" bends and other odd shapes result.

The bending over of a small tree under the weight of a heavy branch or tree-trunk that falls on it also results in producing these seemingly freakish formations.

A curious tree stands on the top of Tunnel Hill, Johnstown, Pa., about four miles from town. It is a sugar maple about one hundred years old which has prolonged its own life by grafting a branch into a much younger tree.

Why There are Defective Babies and Monsters

A cretin, aged forty-two

It is not our purpose in this article to comment upon the ethical right of a physician to permit a defective infant to die. What can science do to prevent Bollinger babies from being defectives? Why are defectives born from apparently normal and healthy parents? The subject has been studied by many scientists and their results are here summarized.—Editor.

A defective who is almost an idiot

BOTH in Sinbad, the sailor, of Arabian Nights' fame, and Homer's Odyssey, there are narrated, strange tales of a monster with one eye in the middle of its head, who was so gigantic and so voracious that he ate two men for breakfast and two for supper, besides emptying three bowls of wine. This creature was called Cyclops or Polyphemus. Another strange formation described in tradition as a "Winged Horse" was Pegasus, the steed of the Muses, which was faster than ordinary horses, because of its wings. Unicorns or horses with spear-like horns are also mentioned in ancient histories as are other human, animal, and plant pedigreed prodigies.

Side-shows, dime museums, fairs and the circus have special departments devoted to exhibitions of Jo-Jo, the Dog-Faced Boy; the Bearded Lady, Siamese Twins; two-headed calves; four-legged hens, and various animal and human monstrosities. The manner in which the odd, contorted creatures are formed, whether they are inherited, like club foot, color blindness, and webbed fingers, or are suddenly caused before birth as the little Chicago baby's deformities were traced to the prospective mother's typhoid fever, has been a much debated medical point.

Dr. E. I. Werber, of Princeton and Yale Universities, has undertaken experimentally to ring the changes on all theories, doubts and opinions by finding exact facts upon which to base the whole problem. It is now possible to attempt an explanation of the strange malformation of the little Bollinger baby born in the Chicago German-American Hospital on Friday, November 12, 1915, which created such widespread interest, because Dr. H. J. Haiselden, the German surgeon, refused to operate to save its life. The principal physical deformities in that much-discussed case were the closure of the intestinal tract, paralysis of the nerves of the right side of the face, the absence of the right ear, blindness of one eye, and malformation of the shoulders. The brain was only slightly subnormal, but the cranial nerves were absent or undeveloped.

"If he grew up he would be a hopeless cripple and would suffer from fits," said the doctor.

A twin egg monster before development

Many of the visitors at the hospital treated the baby, which lay in a little bundle in a private room, as if it were uncanny. Dr. Haiselden alone treated it like a human being. He looked into the little twisted face and patted its cheeks.

"It would be a moral wrong to let it live. It seems to me that a city which allows a Blackhand outrage a week, a thousand abortions a day, and an automobile accident every round of the clock is hardly in a position to criticize a man who holds that death is preferable to life to a defective."

Dr. John B. Murphy, former president of the American Medical Association, and physicians and professional men generally, took sides with Dr. Haiselden. But his critics were just as numerous.

Dr. Rosalie M. Ladova commented: "A life is a life and I wish Dr. Haiselden had stepped out and let someone else operate."

Can Science Prevent Defectives?

The most serious question, however, is how to prevent just such monstrosities as the unhappy Bollinger infant and to this end Dr. E. J. Werber, and independently Professor F. E. Chichester of the Zoological Department of Rutgers College, New Brunswick, New Jersey, have directed their experiments and discoveries.

Before the eggs are made fertile and begin to form the unborn baby, colt, puppy, or other animal, these investigations proved it to be possible to induce such changes in the eggs or early embryos by inoculation into the blood stream of the mother the poison of diabetes, of kidney diseases, of typhoid fever, and other poisons and waste materials, so that deformed offspring would be developed and born. With two substances, butyric acid and acetone, chemicals that are produced in the blood of those who have sugar disease and sugar

Should these children ever have been born? To the left is a cretin; beside her a type technically known as a Mongolian idiot; next comes a micro-cephalic, who is a burden to himself and to the institution in which he is confined; the last on the line is a water-brained (hydro-cephalic) girl for whom society has no use

in the flowing lymph and serum, a great variety of monsters were born in the experiments of Professor Werber.

These experiments yielded defectives and monstrosities, similar to the Bollinger baby, to mythical Cyclops, to Siamese twins, and to creatures without legs, without necks, minus eyes, with absent ear or entire faces, with open spinals, open brains, with tails and without tails, armless, and even clubbed feet. Hydrocephalus, in other words waterlogged head, where the upper part of the head is so elongated as to resemble an Atlas, was produced by alcohol and other poisons in many embryos. In many, parts of the organs were lost, shrunken or undeveloped. Sometimes only half of the body developed. Some eggs were found to have one eye de-

A calf which started to grow a second body

A puppy born without fore legs. It lived six weeks

The skull of a defective pig. The animal had but one eye and no face. To the left, a two-headed calf, one of the common freaks of the old-fashioned "side show"

veloped so large as to crowd out the rest of the body.

The various acids, chemicals, and bacterial poisons used seem to act upon the multiplied egg, after it has subdivided many times into a compound egg. These are fragments broken off by the poisons in the blood of the mother, and the particular divisions which are poisoned cause the malformations and freaks.

Making Hens Lay Double Eggs

Examples of eggs within eggs have been attributed to the serpentine movements of the flexible canal through which they pass. Hens frequently lay several double eggs in succession. Fere, a distinguished investigator, claims that he succeeded in producing double eggs in a hen which normally laid single eggs, simply by drugging her with belladonna. Glaser, another biologist of note, has described the ovary of a hen which habitually laid double eggs and concludes that fusion is the explanation of some double eggs.

The one which Professor Chichester wishes to record is a "gourd-shaped" egg. Professor Hargitt studied one, which was not preserved carefully, and on account of evaporation, the condition was such that he could not be certain of the presence of yolk in the smaller end. He assumed that the egg was comprised of about normal parts in the larger end, and that the smaller consisted of only albumen, "its yellowish tint having resulted from the evaporating process which had taken place."

A twin dog-fish, the result of some chemical effect upon the egg

Many cases of twins and double monsters in fish have been recorded but no case of apparent modification of structure by chemical means in one of the twin fish mentioned. Dr. Chichester fertilized the eggs from several female Funduli by the sperm of one male and at the proper stage, he added a dilute solution of ether in plain sea-water. Many of the eggs died. Two days later the water was changed for fresh sea-water and a few of the dead eggs were removed. Three days from the beginning of the experiment the dead eggs were picked out, and the remaining few were placed in fresh sea-water. The living eggs numbered two hundred and fifteen, and the uncounted dead eggs about six hundred. At the end of six days' time the normal embryos were separated from the abnormal.

A twin fish starting to develop

How quadruple eyes grow

A double head in process of formation

TADPOLE MONSTERS

In the first lot

there were a pair of cyclops, one pair of twins and one hundred and ten normal. In the second lot there were nine typical cyclops and seventy-eight normal. The twin Funduli were most closely observed and were killed and preserved on the sixteenth day only because it was evident that they were about to die. The cyclops was the smaller of the two; the eye on the right side was apparently lacking.

One-Eyed Animals and Men

Dr. Chichester also describes three instances of Cyclops in mammals, one in a rat, and the third in a man.

The man had an hour glass eye in the center of his forehead. The rat had no external or internal indications of an eye; the pig had no eye-ball nor lens, but had three lids, the two upper ones being fused almost completely. Neither the pig nor the rat had a proboscis.

Obviously, monsters and freaks are now in a fair way to be explained without cursing nature for a visitation, which is experimentally traceable to human ignorance, accidents, disasters, and the circumstances that interfere with the natural gravitation of living things toward an even keel, a symmetrical development and the stability of health and a balanced figure.

MARVELS OF MODERN SPORT

The football coach, gripping the lever-handle firmly swings the dummy away from the *tackler as he rushes at it.* The effect is that of an active, dodging, living opponent

Training the Football Tackler

A tackling dummy which moves as if it were a live player running around the end

FOOTBALL as now played is a well-balanced, interesting game, with emphasis laid more than ever on the physical development of the players. During recent years the game has undergone refining at the hands of experienced sportsmen, with the result that open playing is encouraged in preference to the rough and tumble close formation of other seasons. The demand today is for more speed and better generalship.

Football is so strenuous a game that it may not be played without preliminary training. A thorough mastery of the sport calls for the proper coordination of brains and brawn.

A number of mechanical contrivances have been invented to harden the football recruit during his practicing season. Tackling dummies are perhaps the most numerous. They require tactics which are far removed from the actual operation of bringing a player to the ground when he is running at full speed. Throwing a lifeless figure prostrate is entirely different from tackling a moving figure.

Oliphant of the "Army," the human battering ram, carried from one to four tacklers down the field with him when he was running with the ball. No amount of preliminary practice enabled players to halt his terrific rushes. It is just possible, however, that if a tackling device such as that illustrated on the opposite page had been used in teaching the players the rudiments of scientific tackling, Oliphant might have met his Nemesis.

The hollow mast and its various parts

John H. Ashton, a Brown University man, has overcome many of the most serious defects in existing tackling devices. His dummy moves exactly as if it were a live player on a quick run around the end. When the player tackles the dummy, it does not immediately fall to the ground, but furnishes a positive resistance to a downward drag, so that the player must use the same force that he would employ to down an opponent.

The dummy hangs by a steel cable from an arm mounted upon a hollow mast. Attached to the mast, at a point where a bracket meets it, is a handle, used to rotate the frame at any desired speed to impart the proper momentum to the dummy. As the player rushes toward the dummy, the coach pulls the handle, causing the dummy to swerve away from the attack. There is a counterweight in the hollow mast.

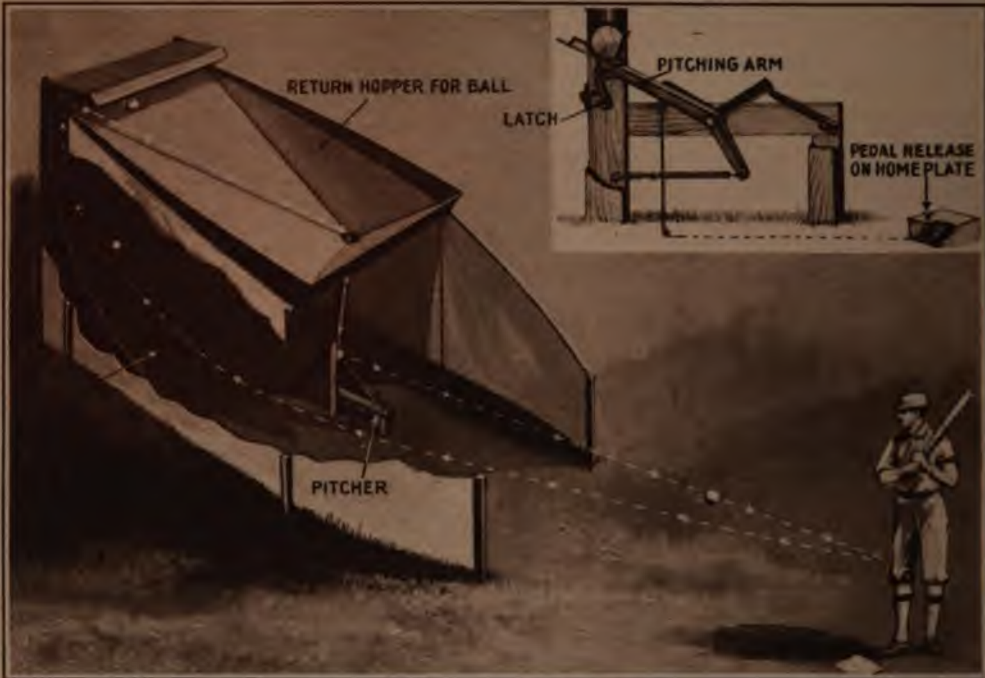
This apparatus for teaching the art of pitching a baseball provides for everything except derisive howls from the bleachers. Both the batter and the catcher are dummies. The catcher-dummy has a cavity for receiving pitched balls, the entrance to which corresponds with the area for a "strike." Above is an indicator for "strikes" and an indicator for "balls." When the pitcher throws a ball over the home plate at the right height, it enters the cavity in the dummy-catcher, drops down a chute and hits the blade of a bucket-wheel. Since the bucket-wheel is connected by belts with the indicator above, the pitcher sees his "strike" recorded. The ball is ultimately sent back to him by a return trough. If the pitcher fails to make a "strike," the ball drops into a bowl in which both the batter and catcher stand. The ball rolls into an opening and falls upon a bucket-wheel, connected by belts with a "ball" indicator. A special trough is provided for the return of the ball

But such games, no matter how ingenious and interesting to those who love baseball for itself, are tame sport for the active and are really only for the sedentary. Much larger and more intricate mechanisms are invented, patented, and operated at country fairs, where the spectator becomes an actual player and pitches against an automatic umpire.

The "automatic umpire" is usually some form of opening in a background.

At the end of a lane formed by rope fences is a wall on which the figures of catchers are painted, as well as enthusiastic occupants of grandstand seats. Two home plates are provided—one for a dummy left-handed batter and the other for a dummy right-handed batter. Immediately behind each home plate is a pad, corresponding with the "strike" area. When the pitcher makes a "strike," the pad moves back, completes an electric circuit, and rings a bell. A spring returns the pad to position, whereupon the bell ceases its ringing and the apparatus is ready for the next pitched ball

A sheet of canvas, stretched on a frame, has an opening the exact shape of the "strike" area to be considered by the pitcher. Back of the opening is a pocket communicating with a trough behind the sheet, leading to the "strike" runway shown. A second trough extends across the front of the sheet and communicates with the "ball" runway shown. Pitch a ball so that it passes into the opening in the canvas and you make a "strike," the ball being returned in its special runway after recording the "strike" on a register in the runway. Pitch a "ball," which means that you fail to land in the opening, and the ball will also be returned by way of the "ball" runway, your inaccuracy being subsequently registered by another recorder



The mechanical batting instructor not only pitches the ball but returns it to the pitching-machine. You simply bat and bat and bat until your arms ache. The ball is sent up an inclined plane, which has a reverse curve at the top, so that the ball finds its way into a hopper and into a funnel leading to a pitching-machine. The insert shows how the pitching-machine works. The ball drops on the upper end of a pitching-arm. As it does so it releases a latch by which the pitching-arm is held against the tension of powerful springs. Suddenly freed, the pitching-arm hurls the ball at the waiting batter. On the home plate is a pedal connected with the pitching-arm. By pressing the pedal with his foot the batter can reset the pitching-arm as fast as he wishes

As one inventor plans it, the chest-protector of the figure of a catcher in lifelike attitude is made as an opening of such size and shape as will accurately represent the plane in space, of which the width is that of the plate and the height the distance between knee and shoulder, through which, according to the rules, a pitched ball must pass in order to be a "strike."

Far more interesting, however, to the average visitor to a country fair is the type of device in which he takes bat in hand and stands in a batting cage, to try his skill with the ash against a mechanical pitcher which actually pitches real baseballs. He does this fearlessly enough; for it is the one great advantage of the pitching-machine that it is never "wild" and never, therefore, at all apt to "bean" the batter (hit him on the head). Some of these mechanical pitchers are but spring-guns designed to fire baseballs at the batter. Others have a figure in front of the gun-barrel which raises its arm, goes through a "wind-up" and makes a throwing motion coincident with the actual delivery of the ball.

To still further extend the illusion and make of the practice of batting a "game," a "mechanical ball field" at a reasonable distance from the batter is sometimes provided. Here a numerous crop of targets appear in serried ranks and various heights. Any one of these targets, hit with a batted ball, registers in a convenient place the "value" of the batted ball. It may be a one, two or three-base hit, a "home run," "grounder," "fly-ball" or what not.

Of the devices actually used by baseball players to train themselves in the art of playing the game, the pitching-machine would seem the most common. The "automatic umpire," however, seems to have some claims to real use.

Ten-Net—An Indoor-Outdoor Game

"Ten-net," the new game, in action. On the left, the net is extended immediately after the ball has been shot. On the right is the attitude of the player receiving the ball

IF "Ten-net," a novel game invented by Halvor Achershaug, of New York, meets with the popularity which is predicted by those who have played it, both indoor and outdoor sports will be forced to look to their laurels.

Many different games may be played with the nets patented by the inventor, ranging from a modified form of handball for indoor work to an exciting outdoor game somewhat resembling lacrosse.

At the right, a player about to shoot the ball into the air for a high "fly;" opening the arms, throws it into the air with great force

A player receiving a ball from a high "fly." The net is held at an angle to catch the ball without having it bounce away

The nets are made of whipcord, fastened to two wooden handles in much the same manner that a hammock is slung between two posts. A triangular loop of resilient spring wire projects from each handle, and to this the edge of the net is securely bound.

In the center of the net is a cradle-like arrangement which is also made of spring wire. This gives added strength to the point which stands the greatest shocks during the game.

In playing "Ten-net," the players use a tennis ball, and throw it back and forth, using the hand nets both in catching and throwing. When the ball comes speeding through the air, the player spreads his net, and allows the ball to hit it. At the moment of impact, the handles are quickly brought together, and the net breaks the force of the ball. A turn of the wrist, and the net is lowered, with the ball held securely inside.

In throwing the ball, the net is used as a sling. The net is relaxed, since the handles are held close together. To get the greatest speed and distance, the net is held be..ind the head, and is suddenly brought forward; at the same time, the hand grips are spread apart. The ball speeds away to an astonishing distance, where it is caught by another player, holding another outstretched net.

Above, a party enjoying a ride on the water with the new water-shoes. The paddles are used to steer and not to propel the shoes. At left, an Italian soldier operating his water-shoes and shooting his rifle

The mechanism of the water-shoe, showing the mounting of the paddle wheel on the pontoons

"Canal Boats" Which Are Real Water-Shoes

AN Italian electrician, Luigi Risso, of Genoa, has invented an ingenious form of water-shoe to which he gives the name "hydro ski." Compared with so-called water-shoes or skis already on the market it differs in the method of propulsion. Unlike forms introduced in the past, the present shoes, which are canvas pontoons, are provided with two sets of cross arms or axles to which paddles are fitted at their extremities.

It will be noted in the illustration that the paddle is fastened to one pontoon by means of an eccentric axle, and to the other pontoon by another eccentric axle. These axles are not in alinement, so that by shifting the weight of the body from one shoe to the other alternately, the paddle wheel is turned at a fair rate of speed with very little effort. Steering is facilitated by the use of a double-blade paddle, which also enables the operator to maintain his balance.

Checkers as an Out-Door Sport

The Dark Squares Are Patches of Grass Showing Through Cut-Out Holes. The Checker Disks Are Shoved from One White Square to Another

Dr. A. George Goldstein Illustrating the Moves and the Ordinary Rules for Playing Out-door Checkers

A RECENTLY invented game called Lawn Checkers, which is sponsored by Christy Matthewson, is being popularized at the Prospect Park Tennis Courts, in Brooklyn, N. Y., and tournaments are being arranged by Dr. A. George Goldstein. The game is played on a 12-foot canvas "board" stretched out on the lawn. The squares are the size of an ordinary table napkin, and the alternate colors are green and white. The green squares are simply square holes cut out of the canvas at the proper intervals. The checkers are red and blue aluminum disks, one side of each being adorned with a star to represent the king or queen. The disks are shoved from one square to another by means of a long bamboo stick.

Teams of from two to twenty may play matches, each player being allowed thirty seconds to make a move. The ordinary rules of chess are followed and prompting is strictly forbidden.

What Inventors Are Doing for the Fisherman

Weedless artificial bait is shown in the upper left-hand corner and above. The air-chamber and ballast cause the hollow metal fish to float horizontally. The wire spring holds the points of the double hook concealed within the body of the bait. A fish grasps the bait by the dorsal fin, depressing it, and the lug forces the points of the hook out of the slots into the fish's jaws. Many species of game fish fight shy of dorsal fins, grasping their prey more to the rear, but this bait is effective, nevertheless

Above, automatic spring gaff trap which embeds barbed ends in the sides of the fish pulling the trigger

Above, a lever-actuated trap hook which barbs the fish pulling the bait. The trap is operated entirely by leverage, the small spring at the pivot joint serving to keep the two hooks separated

Above, the spring hooks are bent back and held set under a hollow wooden cap. A bite pulls the hooks down and the action of the spring forces them into the fish

At left, non-fouling connector so constructed that the hook describes a complete circle without fouling the sinker

Decoy Ducks that Quack and Swim

The ducks are composed of two separable parts which enclose a phonographic contrivance which emits a natural-sounding quack, or call, at predetermined intervals

WHEN Amos C. Vaughan of Anadarko, Oklahoma, goes duck shooting he takes with him a set of his mechanical decoys and places them in the water in front of his blind. Before doing so, however, he winds them up. When a flock of wild ducks appears his decoys begin to swim about and quack as if they were alive. The result is that the inventor goes home with a full bag, for no wild duck can resist the mechanical wiles of his decoy.

His duck is provided with a phonographic means for automatically giving at predetermined intervals a call or cry. It swims about in the water with the aid of the propeller and an adjustable rudder, either in circles or in any direction the hunter wishes.

The decoy is composed of two parts, bottom and top, which can be opened for cleaning and repairing. A clockwork mechanism drives the propeller and also the sound-record of the phonograph. As the mechanism is set in action the stylus, or needle, as well as the propeller is operated. A cylinder or disk is used for the record. A controlling cam renders the needle inoperative at certain intervals, so that the calls or cries are sounded intermittently. Who makes the phonographic record of the quack that leads a duck to its doom? We are baffled.

Dummies That Dance and Play

Wonderful mechanical musicians that smoke, bow, wink and pirouette

TWO hundred years ago, before the days of the steam engine and of the factory, the inventive ingenuity of a mechanic, who was bubbling over with ideas, expressed itself in the making of huge automatons—artificial human beings crammed with clockwork and capable of executing with astonishing fidelity acts which seemed to require the control of a brain. There were automatons that danced minuets, automatons that could write stilted phrases in praise of a reigning monarch far more clearly and correctly than most courtiers, and automatons that even went through the motions of playing a game of chess. They were mechanical curiosities—nothing more.

But it must not be supposed that the art of making mechanical dummies is dead. Indeed, it flourishes more richly than ever, simply because it has been put upon a commercial basis. Only once in his lifetime would an eighteenth century mechanic produce a dancing or letter-writing figure; it was years before he completed his labors. But with the aid of modern factory machinery, automatons are turned out as easily and as rapidly as automobiles. Who wants them? The Coney Islands and the Earl Courts of the world. Somehow the huge, automatic musical orchestras, to the accompaniment of which one eats popcorn and marvels at the tattooed man, are far too tame for the sensation-loving showmen who enliven popular seaside resorts. The orchestrions lack the human touch. And so, the machinery that grinds out the latest dance or the latest song must be adorned with mechanical figures—figures clothed with garish care and very lifelike in their stiff, mechanical way. They beat drums, dance, and juggle; indeed they behave very intelligently and correctly.

Painting the faces of the mechanical musicians in Triboulet's shop

Triboulet of Paris, is the man who invents many of the more ingenious dummies. That he is exceptionally ingenious follows from the very nature of his creations. He must be something of an artist, too; for he devises not only the machinery by means of which figures of wood and metal cut capers, but creates a whole setting like any stage manager.

First of all, a scene is planned Then a model of that scene with all the figures in it is made in plaster or in wax, and a cast taken. If this piece of sculpture turns out satisfactorily, working drawings are made of heads, arms, legs and the like for the guidance of shop mechanics.

The animating mechanism of these huge dolls is complicated enough, as our illustrations prove. The clown who grinds the organ, the pyramid of tumblers, the monkey who plays the piano with astonishing skill, are all operated by spring motors and are wound up like any clock. The machinery within the dummies is operatively connected with the music-producing mechanism. By means of starwheels (little copper plates, regular or irregular in form) levers are thrown which operate subsidiary mechanism for the purpose of making a dummy smoke a pipe, whistle, wink mischievously, bow, and perform a dozen ordinary actions.

Acrobatic and Dancing Dummies

The clown musical director who grinds the organ is a masterpiece of ingenuity

Below: The automatic acrobats, the piano-playing monkey, and the pirouetting clown

Above: Assembling the intricate mechanism which animates the organ-grinding clown

Playing Golf on the Roof

THE already familiar practice net of the golf stores has been turned to the use of finished players by a Boston hotel. On the roof has been set up the usual sort of net into which the player drives, but instead of the canvas back being merely to stop his ball from flying off the roof, it is painted to show what sort of shot he made. On the right are two sections, "low slice" and "high slice," and on the left two corresponding sections, "low pull" and "high pull." Numbers indicate the distance that would be gained by either and whether the ball would go out of bounds before stopping. The central pane is dotted with numbers indicating the lenght of drive which would have resulted on a normal course. Wherever the ball strikes, the canvas shows the value of the drive, as to distance and direction. Below the charts is a space two feet high marked "bunker."

Francis Ouimet trying roof-garden golf on the top of a Boston Hotel

Sleep Outdoors in this Hotel

THE fresh-air habit has at last been recognized by a Boston hotel keeper, who, winter or summer, will let you sleep on his roof under a tent, if you have paid for a room down-stairs. Needless to say this hotel is becoming popular.

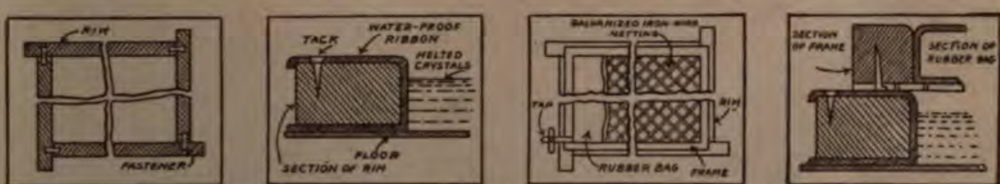
The roof of a hotel on which patrons may sleep summer or winter

Ice Skating in Summer Without Ice

ICE can be made artificially for summer skating. It has the disadvantage of melting. For that reason, chemists have devised glassy surfaces which will stand heat and which will be as acceptable as ice in winter.

Some years ago a German patented a process, in which thick pasteboard plates are immersed in very hot linseed oil and varnish, mixed with glue. After becoming thoroughly permeated with this mixture, they are subjected to a powerful pressure, which squeezes out the excess of oil and gives them great strength. When dry, the plates are immersed in hot paraffin and again put under pressure. To one side of each plate a layer of parchment is applied; the other side is coated with gypsum and tar. The plates, with the parchment sides up, are then fitted together on the floor and united by cement. The finished surface of the rink is coated with a material consisting of one part of glycerin, two parts of wax, and three parts of oil. An unusually smooth floor is thus formed; but ordinary skates cannot be used, since their sharp edges would soon cut up the surface beyond repair.

Another compound contains soluble glass, fluor-calcium, asbestos, ground glass or flint, paraffin and soapstone. These substances, when thoroughly mixed, are applied to the floor. A thin coating of soluble glass and a layer of paraffin are then added. Absolute smoothness is obtained by passing a heated roller over the surface. If the surface becomes scratched, more heat is applied, or fresh coats of glass and paraffin are added.



Diagrams showing treatment of floors. The hot salts are poured into frames on the floor. After solidifying, the frame is removed and used for the next section. The frame with the galvanized-iron wire nets is used in re-surfacing the floor, a rubber bag filled with steam being laid on it. The heat is thus applied without bringing the bag into direct contact with the salts

Skating on Salt

The idea of using crystalline salts, such as the carbonates and sulphates of sodium, potassium and other substances having like properties, has also been suggested. The salts are boiled and then poured directly on a water-tight floor, having raised edges. The floor should be laid in sections, by means of a frame for holding the melted salts. After they solidify, the frame can be used for an adjacent section

The porous substance permits the surplus moisture to pass from the magnesium chlorid to the crystalline top layer or vice versa

This same method has been improved so that a good permanent sliding-surface is obtained. When the rink becomes badly scratched, due to excessive use, heat is applied by means of a rectangular frame supporting a wire lattice-work. The frame is placed on the floor and a rubber bag, filled with steam, is laid on the lattice-work. The action of the heat melts the salts, so that a flat, smooth surface is formed.

Another device for heating resembles an ordinary garden rake. Steam is blown on the floor through a longitudinal slit in a tube. The tube has a handle and two runners for guiding it across the floor. The pipe for supplying the steam passes down the handle and connects with the lower horizontal tube.

This smoothing process is too frequently necessary, owing to the varying degrees of humidity in the atmosphere. To do away with this difficulty, at least partially, one inventor places a thick sheet of sodium carbonate upon a layer of porous material, which, in turn, rests upon a floor having many intersecting channels. Water, circulated through these channels, is absorbed by the porous material and thus comes into contact with the top layer. This tends to prevent the air from affecting the sodium carbonate, but does not completely overcome the difficulty.

Intersecting channels underneath the salts are filled with water to be taken up by the porous layer

The nearest approach to perfection is a combination of substances now being used in Germany with success. Below the porous layer is a sheet of some hygroscopic (water-attracting) substance such as magnesium chlorid. When the air is humid, the excessive moisture from the crystalline top layer passes into the middle porous layer, and then into the bottom layer; when the air is dry, moisture reaches

the salts on top by passing up through the porous substance from the magnesium chlorid below. In this way a good sliding surface is maintained.

Limbering the Muscles of Fire-Fighters

THAT the fireman's life is not all velvet was proved in New Orleans recently, when the fire department turned out in force and did some remarkable feats of quick ladder-climbing for the edification of the public. A tall wooden tower was erected, ladders were hoisted into position, and up these the firemen climbed in record-breaking time. The fire chief was so pleased with the demonstration that he ordered the tower to remain in its original position, to be used in the future for regular ladder-climbing exercise.

In New York, where there is a fire college connected with Central Headquarters to which firemen from all parts of the world come to be enlightened in the latest methods of combating blazes, ladder-climbing forms one of the most rigid courses of training. All sizes of ladders are put up against the rear wall of the college and up these the "rookies" or probationary firemen are ordered by their superiors. At the topmost point of the highest ladder the rookies are sometimes sent with scaling ladders, which they attach to stone outcroppings or window sills and go up fifty or sixty feet further. This is the kind of training which instills a spirit of daring in the men. The training is made to resemble, as closely as possible, the problems involved in the actual work of fire-fighting.

One Reason for Appreciating the Value of Birds

THE fecundity of certain insect forms is astounding. The progeny of one little insect, the "hopaphis," sees thirteen generations born to it in a single year, and would, if unchecked to the end of the twelfth generation, multiply to the inconceivable number of ten sextillions of individuals. If this brood were marshaled in line, ten to the inch, it would extend to a point so sunk in the profundity of space that light from the head of the procession, traveling at the rate of one hundred and eighty-four thousand miles a second, would take two thousand five hundred years to reach the earth.

In eight years the progeny of one pair of gypsy moths could destroy all the foliage in the United States, if unchecked.

A demonstration of firemen's ability in ladder-climbing in New Orleans, La. These men proved so efficient in practical life-saving methods, that their chief ordered the tower to be left in position for the drilling of recruits

Straw Raincoats of Japan

THERE are as many different kinds of alleged waterproof raiment in existence as there are straws in the grotesque costume of the Japanese in the accompanying illustration. But there is just one raincoat which lives up to its rainproof claims, and, in fact, has lived up to them for a thousand years and more, and that is the rice-straw combination worn by the Nippon.

In addition to being light, porous and warm in cold, wet weather it serves as a "blind" for the wary fish which can discern no danger lurking in a fishing-pole protruding from what appears to be a mere sheath of grass. A Nippon angler seated on a river bank wearing his rice-straw cloak resembles so closely a tuft of rank grass or a growing scrub that the most preyed-upon animals fail to detect danger.

From the score of waterproof materials and impervious clothing there is a new Paris product which is said to be very effective, providing one doesn't approach too close to the fire. It is highly inflammable on chance ignition, since its inner lining is composed of guncotton sheeting. There is also an English raincoat which weighs but nine pounds when drv. but which, when worn through rain, will absorb water as readily as a sponge. In an hour it has been known to absorb six pounds of water, adding greatly to its weight and accelerating physical exhaustion. Yes, it's waterproof.

What? Only Three Kinds of Feet?

A RECENT meeting of foot doctors brought forth the information that all feet are divided into three classes, namely, inflared, outflared and straight—the first two classes being scientific divisions for the common afflictions known as pigeon-toes and bow-legs. One doctor said: "Shoes are proverbially made to fit the eye and the pocketbook, but not the feet." In other words the manufacturers have not kept step with the times by making shoes of three classes.

The ordinary classification of boots, shoes and slippers does not fit with the inflared, outflared and straight classes of feet, stated the doctors, as was proved by the fact that most manufacturers ride in automobiles. To remedy the situation it is proposed that all shoes be manufactured to conform with the three general classes of feet that both feet and shoes may advance side by side in the scale of civilization.

The rice-straw cloak on this Japanese is the oldest as well as the most effective of all the various kinds of waterproof clothing extant

MARVELS OF MODERN INDUSTRY

The great Arrowrock Dam, the highest structure of its kind in the world, was recently added to the completed projects of the Reclamation Service. This great irrigation project covers an area of two hundred and forty-three thousand acres, not far from Boise, Idaho. The dam is two hundred and sixty-one feet high, eleven hundred feet long.

The Story of Petroleum

By C. W. Stratford

The author is an engineer connected with a great oil-refining company. His article, while it describes the general principles of oil-refining, is intended to explain how lubricating-oil in particular is obtained.—EDITOR.

THERE is a vast difference between petroleum as it flows from the earth and its derivatives. An oil refinery is a region of giant stills, filters, storage tanks, steam and power plants, coal bunkers and laboratories. Its working population is equal to that of many towns. Immense workshops are required to manufacture the hundreds of thousands of barrels, boxes and tins in which its many products are shipped.

Crude oils are not simple chemical compounds but consist of a physical mixture of different compounds of the element carbon and element hydrogen. Other elements such as sulphur, oxygen, nitrogen and metallic salts, etc., are present as impurities. Each one of these many compounds has its own definite physical properties, such as fixed boiling point, gravity

The Agitator Is a Lead-Lined Steel Tower for Bleaching Oil and for Removing Impurities

Battery of Aerial Condenser for Automatically Condensing Different Distillates, Which Are Then Conducted Through the Water-Cooled Pipes to Their Respective "Running" Tanks

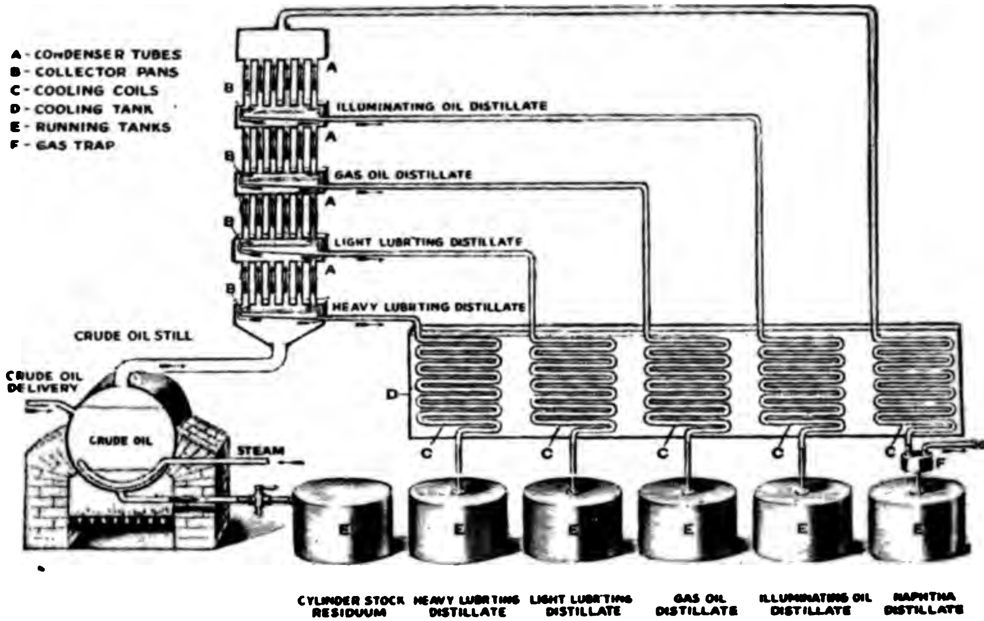


Fig. 1. First Separation of Crude Petroleum Into Groups by Distillation

and other specially distinguishing characteristics.

As cream, butter, cheese, casein, and other products are derived from milk, so are hundreds of different hydro-carbon compounds lying between the extreme limits of gasoline and cylinder stocks or coke, separated from crude oil by fractional distillation. These products are divided into many different grades, according to their physical and chemical characteristics, and to the purpose for which they are used and shipped to all parts of the world, wherever an internal combustion engine is run, a lamp burned, or a wheel turned.

Crude oils may be divided into three main families: those of paraffin, asphaltic and cyclo-naphthene base. There is no sharp line of separation between these groups, since most crude oils found in all fields may contain mixtures in variable percentages of hydro-carbons, belonging to two or more families.

When the crude petroleum arrives through the pipe line and is deposited into storage tanks of large capacity, a certain settling takes place. The semi-solids which settle out consist of amorphous paraffin wax, mud or other earthy foreign matter and impurities.

First Stage—Separation into Groups by Distillation

From the storage tanks the crude oil is pumped into a large cylindrical boiler, called a "crude still."

Distillation as applied to hydro-carbon oil, is the separation of the more volatile portions from the less volatile portions by vaporization, and later condensing them by passing the hot vapors through a cooled tube. Light hydro-carbons like gasoline, vaporize very readily, whereas heavy oils form practically no vapors at atmospheric pressure and temperature; therefore, it is necessary to heat and boil crude petroleum in a closed vessel, in order to accomplish complete vaporization and separation of the different hydro-carbons. Since crude oil is a complex mixture of hydro-carbons, each of which has a different boiling point, a different temperature is required for the vaporization of each compound. Dissolved gas and the lightest hydro-carbons pass over first, and as the temperature is increased, heavier and heavier hydro-carbons are vaporized.

Reverting to Figure 1: The vapors formed are led through a pipe from the still and discharged into the base of an aerial tower condenser. From there they

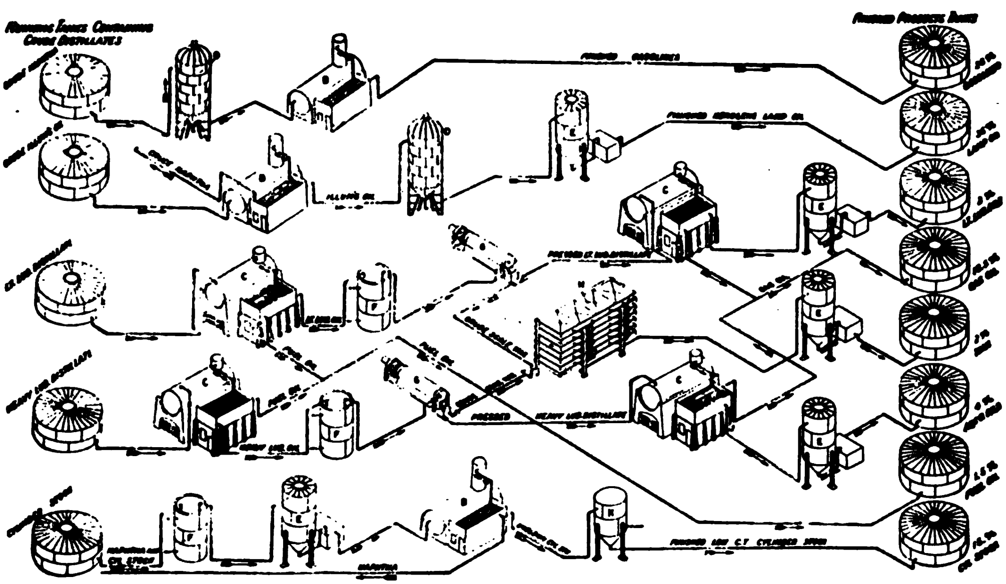


Fig. 2. How Pennsylvania Crude Oil Is Refined

B—Steam Still
C—Steam and Fire Still
D—Agitator
E—Fuller's Earth Filter
F—Chilling Tank
G—Wax Filter Press
H—Wax Sweater
K—Air Drying Tank

pass up through alternate boxes and air-cooled tubes, where products of different boiling points are simultaneously condensed and thus automatically separated into groups. The lightest products pass completely through the tower and flow in vapor form to a water cooled condensing coil, where all light hydro-carbons condensable without the application of pressure, are liquefied and separated from the remaining vapors, which are further treated at a compressor plant, for the separation of very light hydro-carbons from the "fixed" gases. Of the remaining vapors, the heaviest condense upon striking the first air-cooled tubes, and the lightest upon striking the last tubes. Intermediate products, lying between the light and heavy ends, condense in the intermediate tubes, depending upon their respective boiling point. The vapors liquefying in different sections of the aerial condenser fall back into corresponding collector pans, whence each is led by way of a separate water-cooled coil to the storage tanks, called "running tanks." The liquids recovered in the collector pans are still at a temperature above their fire points, and it is necessary to cool them down to prevent spontaneous ignition, when they come into contact with air in the running tanks.

Distillation continues until a residue (crude cylinder stock), of about 15 per cent. remains, when the fires are drawn and the remaining oil is pumped from the still through a cooler into a running tank.

The quantity and quality of products obtained from this first separation depend upon the method of distillation employed and from the base or "family" to which the crude petroleum belongs. This description, however, only concerns Pennsylvania crude oil of paraffin base. High quality oils are obtained when the separation is made by distilling under vacuum or by the use of fire in combination with steam injection. Due to the mixture of oil and water vapors in fire and steam distillation, oil vapors pass over at lower temperatures than were fire used alone. This prevents the occurrence of any serious "cracking" of the heavier products.

Second Stage—Separation and Finishing of First Groups

The prime object of subjecting the group-distillates from the running tanks to different processes is to furth[er]

separate each group into the final market form of the many products contained.

The secondary purpose of refining is to remove the impurities, color-bearing, and unstable or unsaturated compounds and free carbon. It may be well to point out at this time that in the first group distillation there is no sharp line of demarcation between gasoline and illuminating oil or between any other similar fractions. Heavy constituents are mechanically carried over with the light portions and more volatile products are mixed with the heavy parts. In order to completely separate these, further distillation is necessary.

Fig. 3. Fuller's Earth Filter

The crude naphtha distillate is pumped from the running tank to an agitator where it is treated with sulphuric acid, washed with water to remove the free acid and neutralized with caustic soda, again washed and separated from the water. The treated naphtha is next sent to a steam still where it is divided by distillation into various market grades of gasoline and pumped from there to the finished naphtha storage tanks. (Fig. 2.)

The illuminating oil distillate is pumped to a steam still where the crude naphtha contained is separated by distillation and sent to the crude naphtha still. The illuminating oil remaining is sent to an agitator where it is acid treated, washed, neutralized, rewashed and filtered through Fuller's earth (Fig. 3) and pumped to the finished kerosene lamp oil storage tanks.

The crude light lubricating distillate passes from the running tank to a steam and fire still, for the purpose of changing (by heat) the character of the paraffin wax from the amorphous condition to wax that may be crystallized and for separating the fuel oil content. The lubricating distillate then goes to a chilling tank where its temperature is lowered to such a degree as to cause crystallization of the wax. In this chilled condition it is then pumped to a wax filter press, under high pressure, where it is separated into crude scale wax and pressed lubricating distillate. The pressed distillate then goes to a steam and fire still, where the gas oil is separated from it. The remaining distillate is then divided into lubricating oils of different viscosity, varying from very light to medium light, by fractional distillation.

The oils of different viscosities resulting from this fractional distillation are next sent to a Fuller's earth filter for the removal of color-bearing compounds and free carbon. From the filter, these oils are pumped to the finished lubricating oil storage tanks.

The crude scale wax is sent from the wax filter press to a sweater, where it is separated into scale wax and oil. The scale wax then goes to a Fuller's earth filter, through which it passes to the finished paraffin wax tanks.

The crude heavy lubricating distillate follows the same course in processing as that indicated for the light distillate. Fuel oil and paraffin wax are separated in the same manner. The fractional distillation of the remaining oil results in lubricating oils of heavier body than those recovered by the processing of the light lubricating distillate.

Crude cylinder stock is greatly thinned with naphtha, and then sent to a chilling tank where the paraffin wax, from which vaseline is made, settles out. The oil-naphtha portion is pumped to a Fuller's earth filter for the removal of color-bearing compounds and free carbon. From the filter it passes on to a steam still where it is separated into naphtha and low cold test cylinder stock. From the still the oil is sent to a tank where it is blown with air to remove traces of moisture and then to the finished storage tanks.

Minute Men of the Rails

Much of the fascination of railroading centers around the wrecking crew and the important and ofttimes gruesome work of clearing wreckage and keeping the lines open

WRECKING-TRAINS are located on every division of important railroads, standing idle in the yard, waiting for calamity. A crane-car, with sufficient power to lift a freight-car as a child lifts a toy; a supply-car, containing rope, cables, chains, jacks, crow-bars, tools, lanterns, fire apparatus, dynamite, rails, ties; a caboose for the wrecking-crew.

When the word comes over the wire that the express and the fast freight have tried to see which could butt the other off the track, the wrecking-crew assembles in a hurry. They are picked men—these minute men of the rails—each with his specialty. Mechanics, track-men, men skilled in explosives, strong men, slender men, at least one small but muscular man, they come from roundhouse and shop, freight yard and office, at the supreme call. The wrecking-boss takes command, the best engine available backs down, and with a clear track the wrecking-train gets to the disaster, often ahead of the special containing doctors and nurses.

There is only one order to be obeyed when the wrecking-crew gets in action—"Save life." But once the victims are extricated—and they are taken out in a remarkably short time—the order changes. It is not, as might be expected, "Save property." It is "Clear the lines." It makes no difference that five jumbled freight-cars contain expensive automobiles, or pianos, or phonographs, or fruit, which might be saved by careful work. If the contents cannot be saved in less than an hour, there is only one thing to do. The big steam crane is backed down to the mess, a long, tentacle-like hook descends, chains and ropes are brought into play, and slowly, surely, almost daintily, the crane swings the wrecked freight-car and its contents to one side.

Sometimes the easiest way to clear the lines is to burn the wreck or blow it up. Track can be quickly relaid, if damaged, but nothing can replace lost time. The price of a cargo of automobiles is nothing against a five-hour delay. For the price of delay mounts in stunning geometrical progression. A few hundred dollars for the first hour, it may be many thousands of dollars in the second or third hour. A stoppage

A wooden coach stands at one side cut in two as if with a giant saw. Behind it stands an impatient express and behind that a long freight train. In the other direction a local is filled with fuming commuters and perhaps the President's special is close behind. All along the division and soon to spread through the whole system is delay, stalled trains, trains waiting orders, trains costing the railroad company thousands of dollars a minute to operate

The crane can pick up and transplant five tons of twisted steel as easily as a nurse can lift a baby from a perambulator. When the great tentacle-like hook descends, chains and ropes are brought into play, and slowly, surely, almost daintily, the crane swings the wreck to one side. If it cannot be lifted it is burned or blown up. The price of a cargo of automobiles is nothing compared with a five-hour delay or the disruption of a railroad's train schedule

Above, the crane has its "hands full," but fortunately for it the car is of steel and can stand the heaviest pull

Above, a locomotive with a ruined "face." Such wrecks almost always cost human life

A slip and slide into the river is all that happened here, but it took a complete track-laying gang in addition to the wrecking-crew to get the line open again and restore train schedules

The wreck occurred a considerable distance from this bridge but the threshing machine, mounted on a flat car, was hurled with such force that it struck the bridge and broke through

The doctors and the nurses and the relief-train have come and gone; down the line stands an impatient express, behind it a long freight. In the other direction, a local is filled with fuming commuters and perhaps the President's special is close behind. All along the division, and soon to spread through the whole system, is delay, stalled trains, trains waiting orders, trains costing the company thousands of dollars a minute.

Over the tangled debris one man stands supreme, snapping his orders like the crack of a whip, utterly unmindful of the property he destroys that other property may move. And, as if by magic, the lines clear. The last of the bent and broken cars are turned on their sides and slid down the bank. The injured engine limps off behind a fussy switch-engine sent for the purpose. If the delay looks long, a temporary side-track has been swiftly built and the several waiting trains puff slowly by. The wrecking-train whistles. Its crew, driving the last spike to make the injured track secure, pull out jimmy-pipes. The big crane folds its single arm and rests. The men pile into their caboose. The wreck is off the lines—time, fifty-five minutes. The wrecking-train has finished its work.

of the lines may mean a stoppage of the whole railway system, with hundreds of thousands of dollars worth of freight tied up, confusion, loss, waste.

And well he knows his work. The crane for this car, the jacks for that. This engine looks like scrap but will probably run; put her on the other track. That engine looks all right but is vitally wounded; throw her off. This car is too inextricably tangled with another in loving embrace to take to pieces, part by part; burn it up and throw the trucks to one side. The small man, a necessary factor, crawls into and out of openings and holes too small for his stronger mates, attaching chains and ropes, reporting conditions, doing work as valuable as that of the Hercules who, with a crowbar, heaves up a tangle of wheels that a jack may be slipped into position.

Twelve Million Dollars for Twenty Minutes Train Time

TO cut twenty minutes from the running time of passenger trains and one hour from the running time of freight trains between New York and Buffalo, the Lackawanna Railroad has invested twelve million dollars in a concrete arch half a mile long.

This beautiful viaduct built of concrete, cuts twenty minutes from the train time of the Lackawanna between New York and Buffalo, but it also saves miles of heavy grades

By the old, circuitous route, due to the heavy grades, five engines were required for the work that two can now do comfortably.

The new viaduct is an imposing structure crossing the Tuckhannock Valley in ten graceful arches. It is of concrete, the largest concrete structure in the world, containing more than five hundred million cubic yards of material. Some idea of its vast size can be gained by a comparison with the dimensions of better known structures. If the Flatiron Building were eight blocks longer, it would have practically the same dimensions as the Tuckhannock Viaduct. If the roadway of the Brooklyn Bridge were one hundred feet higher, it would have the dimensions of the viaduct.

Including the viaduct, the total length of the cutoff is three and one-half miles. The old route is thirty-nine miles.

Niagara on Tap

By Professor Thomas H. Norton

To what extent should Niagara Falls be sacrificed in the production of electric power? Each year witnesses a growing bitterness between two factions: The one insists that no scenic treasure shall be permanently marred by servitude to the demands of commercialism; the other claims with almost relentless logic, that in the case of Niagara, the right of the nation to utilize the enormous power available, shall not be subordinated to a mere sentiment. Professor Thomas H. Norton, in a paper which he read before the American Electrochemical Society, outlined a scheme whereby it would be possible to satisfy those who see only the beauty of Niagara, and those who see only power going to waste. The following article by Professor Norton is an abstract from the paper in question.

THERE must be some practicable, workable thesis, according to the terms of which, on our own continent for example, the rights of its inhabitants shall suffer no material diminution in the opportunity to fully enjoy the splendor of Niagara, while conditions are created which permit the utilization, on a satisfactory scale, of the tremendous source of power,—one of the nation's grandest assets.

The principle of an *intermittent waterfall* would appear to offer a simple, but thoroughly practicable solution. It may be briefly formulated as follows:

During somewhat more than half of the twenty-four hours, especially during the night time, a waterfall is completely harnessed. Every kilowatt which it is capable of creating is devoted to the service of industry. During a shorter period—from ten A. M. to eight P. M.—the cataract resumes its normal activity, contributing to the esthetic enjoyment of all who behold it.

In the case of Niagara, naturally the most familiar of the world's great cataracts to the readers of the POPULAR SCIENCE MONTHLY, the application of the intermittent principle would offer no difficulties of an engineering nature. The topographic factors are simple.

To harness completely the great mass of descending water is a matter of comparative ease. The expense would be far less than that required for the monumental Assouan Dam of the river Nile,—five hundred millions. It would probably not exceed two hundred millions at the outside.

One-quarter of a mile above the western extremity of Goat Island, where ripples betray the beginning of the upper rapids, a dam would be constructed at right angles to the axis of the river. The length would be about four-fifths of a mile. Niagara River at this point is exceedingly shallow. Equidistant soundings from the American shore to the Canadian shore show an average depth of 3¾ feet. It is evident that the construction, based upon the rocky bed of the river, would be relatively easy and inexpensive.

The dam would possess the necessary architectural features to harmonize with the environment. The water impounded by the closing of the gates could be led by huge canals, on both sides of the gorge, to the edge of the bluff overlooking Lake Ontario. From this point a multitude of penstocks and rock tunnels would conduct the entire volume of water to the level of the river near Queenston on the Canadian side and Lewiston on the American side, where battalions of power-houses can easily be located.

The total section of the system of canals and penstocks required for the complete utilization of the average flow of Niagara River would be approximately sixteen thousand square feet. The mean flow of water, with a hydrostatic head of nearly three hundred and fifteen feet,

"In the deep recesses behind the falling sheet of water at Niagara," says Prof. Norton in his article, "a gigantic system of scaffolds would be erected. These would serve as the supports of a series of over-shot wheels or endless-chain bucket wheels. By careful disposition a considerable fraction of the available power—possibly thirty to forty per cent.—could be utilized without revealing any portion of the mechanism to the eye of the beholder"

would produce about seven million, four hundred thousand horse-power.

Once provided with the mechanical means to control the vast volume of water, ordinarily sweeping over the crest of Niagara, the daily program would be as follows:

At 8 P. M. the entire series of gates on the dam would simultaneously close. A few minutes later and the American Falls would falter. The volume of water would swiftly diminish. Soon the grand curtain would be rent and gashed as if by invisible knives. A minute or two more, and rivulets here and there pour over the brink. The gloomy, cavernous recesses beneath the overhanging edge are revealed to the eye. Another minute, and the rivulets have changed to drops.

From Goat Island to the apex of the great Horseshoe the same sequence of transformations begins. It creeps steadily along the crest until it reaches the Canadian shore. The deafening roar of the cataract sinks to an agonizing groan, a reproachful sigh, a dying murmur. Niagara is silent!

A few minutes later and the rage and fury of the long stretch of rapids in the picturesque gorge falter and slowly subside. The vast volume of water between the foot of the falls and Queenston gradually drains away. A quiet lake remains between the railroad bridges and the base of the falls. Its surface is about eighty-six feet below the normal level, and the enclosing cliffs gain that much in height. It would be somewhat narrower than the present river, and frequent rocky islands would appear near the temporary banks.

For three-quarters of a mile the relatively narrow and shallow bed of the whirlpool rapids would be laid bare. The whirlpool itself would remain a somewhat restricted and motionless sheet of water, forty feet below its normal level, at the head of a quiet fjord, extending inland from Lake Ontario.

Such would be the topographic changes attending the harnessing of the cataract.

Synchronously with the vanishing of the falling tons of water, in thousands of workshops scattered over the fruitful territory of Ontario and New York, a million, perhaps many million, workmen begin their daily task. For fourteen hours the world's greatest beehive of industry is filled with the busy hum of activity, keyed to the highest pitch, banqueting, as it were, on the corpse of a murdered Niagara! One shift of seven hours is succeeded by another of the same length. All the energy of the seven million, four hundred thousand horse-power is devoted to the welfare of the nation.

It is 10 A. M. As the signal is flashed from the National Observatory the gates of the great dam shoot upward. The hum of spindle and loom, the clang of the triphammer, all the many-toned gamut of sound which forms the orchestral accompaniment of a busy, happy people shaping, fashioning, creating the objects of convenience or luxury destined for each other's comfort or enjoyment,—all sink to a whisper,—vanish!

A minute later and the crest of a vast billow sweeps over the brink of the American Fall. In an instant, almost, with a deafening roar of exultant joy, the cataract has sprung into full activity. Swiftly the falling curtain spreads from Goat Island along the crest of the semicircle, until Niagara, in full panoply of power and might, hurls her defiance at the assembled thousands gathered to witness the most wondrous sight on the face of the globe—the rebirth of a cataract. The spectacle would combine all the swiftness of movement and stupendous grandeur offered by the sweep of the Johnstown flood, or the tidal wave of Galveston, free from the tragic terrors and horrors of those cataclysms. The gloomy, beetling cliffs disappear behind the sheet of foam and spray; rainbows hover in the clouds of mist; the gray walls of the gorge echo back the roar of the proud cataract!

In a less dramatic and spectacular manner the level of water in the gorge would steadily rise; the foam and spray of the rapids become evident; the whirlpool resume its circling activity; and Niagara's normal life reappear.

For ten hours the thousands of machines, of furnaces, of electrolytic vats rest or are available for repairs, until the sun sets, and in the twilight the hour approaches for an eager multitude to witness again the death agony of a cataract unequaled in size.

A view of Niagara Falls when, a few years ago, ice dammed the river above and shut off all but a small proportion of the water. One of Prof. Norton's plans would denude the falls each night still more than is shown here. When the water diverted by his dam to the running of his power plant, the "grand curtain would be rent and gashed as by invisible knives, a minute or two more, and rivulets here and there would pour over the brink . . Another minute, and the rivulets have changed to drops . . . Niagara is silent!"

Such would be the daily sequence of events. On holidays, on the Sabbath, the lovers of nature could view the falling sheet of water at all hours of day and night, in the twilight, at dawn, in the solemn quiet of midnight.

When used for motive power on railways, street-car lines, etc., in many branches of electrochemical industry, continuity of current is imperatively necessary. Storage batteries may be employed, but at an increased cost for each electrical unit.

It is, however, perfectly feasible to rescue a very large proportion of the power, ordinarily going to waste during the shorter period of the day, when the cataract resumes its normal activity, without affecting, to any noticeable degree, any elements of its scenic beauty.

In the deep recesses behind the falling sheet of water at Niagara, the Cave of the Winds, etc., a gigantic system of scaffolds could be erected. These would serve as the supports of a series of overshot wheels or endless chain-bucket wheels. By careful disposition a considerable fraction of the available power—possibly thirty to forty per cent—could be utilized and directed to electrochemical or transportation centers without revealing any portion of the mechanism to the eye of the beholder gazing at the cataract. There would be a noticeable increase in the volume of spray, which could tend only to heighten the scenic beauty of the waterfall.

The simplest means to accomplish the purpose would be a series of buckets, operating on endless belts, working on axes located immediately beneath the brink of the cataract and at the base of the falling sheet of water. Essentially an enormous overshot water wheel. with its modern effective devices on the periphery, distorted and elongated into the form of a belt, as used for the transmission of power from one shaft to another. A complete series of such elong[illegible] wheels, closely adjusted side by [illegible]

would occupy the entire space behind the curtain of falling water, as far as their presence could be concealed from the view of those on the adjacent banks.

It is scarcely necessary to state that during the fourteen hours of enforced quiet and rest, while the waters of the Great Lakes are diverted through a maze of penstocks, to dash upon thousands of turbines, the sight of a serried array of mechanical devices, lining the cliffs of Niagara, would be sadly out of harmony with the otherwise gloomy grandeur of the gorge.

Although this period covers the time ordinarily devoted to slumber, still in the evening and during the early forenoon, tourists and others would constantly gaze upon Niagara at rest.

To remedy this feature, one per cent or less of the river's volume would be allowed to pass the dam, and flow over the brink. It would generate a thin curtain of water, just enough to hide the massive scaffolding and the maze of wheels. By simple hydraulic devices, this small amount of water could be largely transformed into spray. A delicate lace-like "bridal veil" would screen cliffs and every trace of commercialism.

The initial outlay would scarcely exceed two hundred million dollars. This is equivalent to a capital outlay of twenty-seven dollars per annual horsepower, based upon continuous use. The annual interest charge would be less than a dollar seventy-five. This approximates the rates of two dollars per annum in Iceland and of three dollars on the west coast of Norway. At present the electric power of Niagara costs twenty dollars per annum.

It would mean the creation of an industrial metropolis, surpassing any now existing on the face of the globe. No cinders or soot would pollute its atmosphere; no towering chimneys would rise against the sky-line. Industries of the most varied nature, carbides, carborundum, aluminum, cynamid, chlorin, alkalies, steel, copper, and many minor branches—all dependent upon the electric current—would gravitate to this point. It would become in very truth—perhaps in name—the *electropolis of America!*

A Mile-a-Minute with an Air-Driven Sled

IT was doughty old Count von Zeppelin who first pointed the way toward locomotion with an air propeller. More than fifteen years ago, when he first planned the giant, rigid airships which are now known by his name, he had to conduct a series of experiments in order to obtain propellers of sufficient thrust for his huge untried craft. Accordingly he mounted them upon a boat and made experiments on Lake Constance. The speeds which he attained were not more than twelve miles an hour, but they were sufficient to prove that he could urge his first giant vessel through the air at forty miles an hour.

The idea reappeared in France at a later date. Ordinary launches as well as specially constructed hydroplanes were driven on the Seine by propellers revolving in air. Tissandier and Santos-Dumont made speeds as high as fifty miles an hour on water. As in Count von Zeppelin's case, their experiments were prompted by the thought of obtaining a system of propulsion for air boats. So successful were they that a few motorcycles and automobiles appeared thus propelled.

Now comes an American manufacturer who reduces the idea to commercial practice. He has constructed an air-propelled sled with which it is possible to obtain a speed of sixty miles an hour over ice or packed snow. An engineering experiment, to test out the possibilities of an aircraft, has been developed commercially. The air-propelled icecraft is now a vehicle of sport.

Notice the construction of the sled as it is depicted on our front cover. Upon a frame supported by the two rear runners a gasoline engine is carried, by which the air propeller is driven. A string-piece connects the motor-carrying frame with the single forward runner. There is room for two men. The rear man does the guiding with an automobile steering-wheel connected with the forward runner, which is pivoted so that it acts as a kind of rudder. Stop the motor and the whole sled can be checked and brought to a standstill very quickly by a powerful emergency brake.

The World's Largest Flagstaff

Unloading the largest flagstaff in the world. This huge timber was brought to London from British Columbia, and is shown being towed up the Thames to Kew, where it will be erected in Kew Gardens

A HUGE log, two hundred and fifteen feet long, and weighing eighteen tons, was recently transported from British Columbia to London, to be erected as a flagstaff in Kew Gardens.

The transportation of this great timber across the ocean presented unusual difficulties. The pole was finally secured to the deck of a steamer, close to the rail, much to the discomfort of the ship's passengers.

Upon its arrival in London, a number of cranes, operating simultaneously, slid the timber free from stanchions and deck houses, and dropped it into the water, where a line was secured to its butt to tow it up the Thames River to Kew, where it will be erected.

What Shall We Do for Gasoline?

THERE are about two and one-half million automobiles in use at the present time. By the end of the year their number will be well over three million. All of them consume gasoline. There are also three hundred thousand motor-boats, forty-five thousand motor-trucks, thirty thousand gasoline farm tractors, and an untold number of stationary engines, all dependent on gasoline. Over thirty-five million barrels of gasoline are annually required to meet the demands of these many motors.

The total gasoline content of all the oil produced in this country in 1915 is estimated at 1,892,500,000 gallons.

According to the preliminary report on the investigation of the rise in the price of gasoline, prepared by the Federal Trade Commission, the 1915 exports of gasoline amounted to fifteen per cent of the entire gasoline content of all the crude petroleum produced in the United States within the year 1915, Exports for the year of gasoline, naphtha, and benzene totaled eight hundred and twenty-four million, five hundred and fifty thousand gallons, as against two hundred and thirty-eight million, five hundred thousand in 1914.

We are burning up gasoline faster than we can distill it from the crude oil which we pump out of the earth. In past years so much gasoline was produced that some of it could be set aside for possible later emergencies. But even these stocks are now practically exhausted and we are living almost from hand to mouth.

It has been suggested that benzol be used. Not until the war began did the United States of America make any serious attempt to recover benzol as a by-product of coke making.

Benzol is not greatly different from gasoline. Motorists object to it because it requires adjustments in the motor. Moreover, the quantity of it available will always be so limited as to preclude widespread distribution.

What is known as casing-head gasoline has been finding increasing favor. Casing-head gasoline is literally squeezed out of natural gas just as you squeeze water out of a sponge. The output of gasoline thus extracted is about one million and a half barrels a year.

In the ordinary method of distilling petroleum, heat is applied. At low temperatures the vapors of the lighter constituents of the oil are distilled off and condensed. As the temperatures increase the heavier vapors rise; finally a heavy mass is left from which no fuel at all can be distilled. The line of demarcation between gasoline and kerosene is ill-defined. Hence in the days when the kerosene lamp was in vogue and when gasoline could not be sold for lack of automobiles, the oil refiner retained as much gasoline in his kerosene as he dared. Nowadays the situation is reversed. Gasoline contains as much of the kerosene element as possible. From year to year, gasoline is becoming heavier and heavier. But even this device of the refiner, made necessary by the enormous demand for motor fuel, has failed to meet the situation. So, for years oil chemists have been trying to devise plans whereby kerosene itself could be subjected to further heat treatment—a heat treatment which is known as "cracking," and which serves to break up the kerosene molecules into gasoline molecules. One of the most successful of these processes is that invented by Dr. Burton. Thanks to him at least three hundred thousand automobiles are now running on cracked gasoline. More recently Dr. Rittman has come to the public notice as the inventor of a cracking process for which marvelous things are claimed. Dr. Rittman believes that the cracking process will solve the gasoline problem.

A cheap motor fuel is a vital necessity to the automobile industry. The cheapest at present available is kerosene. But unlike gasoline it demands a special type of carbureter—an apparatus which will perform its function far more scientifically and accurately than is necessary with gasoline. If present indications mean anything at all they mean that motor car manufacturers will develop a type of carbureter which can be successfully used with kerosene.

Where the Modern Farmer Spends His Evenings

Plowing a field at night with the aid of two powerful lights which enable the operator to see the path ahead of the machine he is driving, and the width of plowed field in its wake

Threshing after sunset. The arc light derives its current from a dynamo which is belt-driven from the threshing machine. In this way the farmer makes hay while the electric light shines

Machines That Smoke Cigars

The Modern Way of Sampling Tobacco Leaf

Above, the aspirator and siphon apparatus for testing tobacco leaf. It smokes four cigars in thirty minutes. At left, the blower outfit which is operated by electricity. The smoke is coming from the exhaust outlet

THERE are tea-tasters, perfume-smellers and silk-feelers, but when it comes to smoking cigars to determine their uniform burning, their ash color, and the aroma of the smoke the human element is entirely dispensed with and machines—cigar-smoking machines that can smoke four cigars at once and never smoke themselves to death—are used. These are of two kinds. The cigar buyers use a simple blower outfit, and the Bureau of Plant Industry of the Department of Agriculture tests its tobacco leaf with an aspirator and siphon apparatus.

When the buyers come to New York for their season's supply of tobacco they take the blower machine with them, and after selecting certain qualities of tobacco have cigars made up on the spot, connect the blower to an ordinary lamp socket, insert the cigars and watch results. The way the cigar burns, the color of its ash and the aroma of the smoke are indications as to the quality and desirability of that certain brand.

The Bureau of Plant Industry has an interest in tobacco entirely different from the cigar buyer. It is endeavoring to improve tobacco by a scientific study of the different brands. To eliminate the personal equation in smoking and to secure uniformity of conditions the Bureau has a unique apparatus for testing the burning quality of cigars. The "pull" on the cigar is secured by means of an aspirator which is filled by a continuous inflow of water and emptied at regular intervals by a siphon. The "pull" occurs at intervals of thirty seconds and continues for a period of ten seconds. The apparatus smokes four cigars of the perfecto type in about thirty minutes.

There are several elements which go to make up a good or bad burn, chief of which are the capacity for holding fire, the evenness of the burn, the color of the ash and its firmness, the coaling or carbonization, and the "puckering" of the leaf immediately in advance of the burning zone of the cigar. The final test of any cigar tobacco must, of course, rest in the smoking of the manufactured cigar, but, while this gives a direct means of determining the character of the ash, it does not furnish accurate information as to the evenness of the burn or the fire-holding capacity of any one of the components used in the experiment. Tests have been made using different fillers and binders with the same wrappers.

Catching Fish by Suction

The vacuum cleaner principle applied to fishing on a wholesale scale

A suction pipe is connected with a funnel-shaped net and a centrifugal pump, by means of which the fish are drawn up and deposited in a container on board the boat

THE fish of the deep are getting wiser, if one can take the numerous devices invented for their capture as a criterion. Nets used by fishermen for centuries are apparently being discarded in favor of more recent fishing inventions. One of the most recent of these is an apparatus for enticing the fish into a net and then drawing them up through a pipe to a container on deck. C. P. Droz, of Nilversun, Holland, is the inventor.

The apparatus comprises a suction pipe connected with a centrifugal pump, a source of light such as an enclosed electric lamp placed in front of the suction opening, and a funnel-shaped net so arranged as to guide the fish to the suction opening. The fish, seeing the light, enter the net, approach the suction opening and are drawn through the pipe and delivered to a container on deck.

Steel hoops brace the net and strengthen it so that it retains its shape in spite of the action of the waves.

The net is secured at its rear end to the suction pipe and at its front end to a frame pivotally suspended from the boat, so that the net can be removed from the pipe and raised together with the frame to the position shown by the dotted lines in the drawing.

There is a recess made in the boat into which the pipe may be raised and stored away when it is not in use.

The Giant Task of the Subway Diggers in New York

By Charles Phelps Cushing

IS there anywhere in New York tonight a cross section of street-life more dramatic in contrasts than the bit of Broadway in front of the Metropolitan Opera House? The Great White Way is gay, thronged, and glittering. The opera is just over; crowds in evening clothes, silk-hatted and the bejeweled, are pouring out to their waiting limousines. There, as in past years, the pageant of wealth parades—but this season with a difference. The sidewalk and the pavement of Broadway are now rough planks, and from below this rumbling floor the shrill tattoo of a drill resounds upon rock. Picture this cross section:

Above that plank floor, the silks and jewels and glittering lights; below it, in half-darkness, a squad of laborers in greasy overalls, stained with sweat and mud, risking their lives to build another subway.

New York rarely gives a thought to its thousands of sappers and miners.

"Building another subway," it says. "Wish they'd hurry and get it over. They've torn up half the town."

So a khaki army in the subway trenches hurries, by day and by night, risking life and limb like soldiers. The peril of the job is a story in itself, not to be told in a paragraph. Suffice it, for the present, to say that only a few yards farther down the same street one person was killed and three persons were wounded a short time ago when a layer of "rotten stone" slipped into the subway ditch and half a block of the floor of Broadway followed it.

Transporting Three Billion People in a Year

The average resident of New York has very little comprehension of the vastness of these great engineering operations. Is the human mind able to picture

The simplest method of building a subway, known as the "cut and cover" method. If the entire length could be built with open construction, the engineers would have a comparatively simple task. The twisted vertical steel rods are the reenforcing members for the concrete walls

In the illustration below may be seen one of the many trestles which carry gaspipes across a torn-up street. After one serious explosion, New York put these pipes in the air where leaking gas would escape without danger of a catastrophe. The average cost of doing this is twenty-five hundred dollars; and where larger distribution mains must be handled, the cost runs as high as ten or eleven thousand dollars

The great tangle of pipes and conduits shown above must all be separated and placed within narrow confines, since they interfere with the progress of the tunneling. Great patience, as well as ingenuity, must be exercised in unraveling these tubes without accident. Below may be seen a section where open construction is employed. Many square miles of pavement have to be torn up to prepare for the digging operations. After constructing this part of the subway, the earth is again filled in above, new pavement has to be built, and the interior work is then completed

An engineering undertaking of tremendous difficulty. This honeycomb of tunnels at the Grand Central Station, at Forty-second Street and Park Avenue, New York, is being dug

eight hundred million people? That is the number of passengers the present system of rapid transit in New York (elevated lines and subways combined) can transport in a year. This carrying capacity is being increased to three billion! When the new system is completed it would stretch, in single track, from New York's city hall into the borders of Eastern Tennessee, some six hundred and twenty-one miles. The cost of the new lines and extensions amounts to three hundred and thirty million dollars, which is to say, as much as the government has thus far expended at Panama. No other urban rapid transit system in the world will compare with New York's in magnitude.

The new subways—in single track, the total amounts to more than one hundred and fifty miles of tube and trench—are the most interesting side of the construction now in progress; for this work is at once the most difficult and the most

through treacherous and rotten rock, and has to be built without disturbing the traffic in the present interborough subway, which is to be seen on the second level in the illustration

perilous. New underground routes are being driven through some of the world's most crowded streets, and without materially interfering with the traffic. Though the typical construction is a covered ditch with a roof which is only a foot or two below the floor of the street, there are many places where real tunneling and mining operations are required. The digging goes on under a variety of conditions: through underground swamps and watercourses, through treacherous rock, through sand and even through quicksand. At the south end of Manhattan Island two new sets of tubes are being driven under East River; at the north end a set of tubes was built on shore and then towed out into place and sunk on the bed of the river. In Lexington Avenue a new idea in subway building is presented in the form of an underground double-decker. At Grand Central Station the earth is being honeycombed into five levels.

The new local tracks beneath Lexington Avenue near 74th Street. It will be noticed how free the street is from serious obstruction. This system, extended in a single track, would reach from New York's city hall into the borders of Eastern Tennessee, some six hundred and twenty-one miles

These are some of the more striking features of the work; but even the matter-of-course features loom big when one comes to inspect them closely. To make room for the subways, the space just below the street level has to be vacated of all its various pipes. The expense of moving them is enormous. Take, for example, one item, the cost of relocating sewers. Sixty miles or more of new pipes are being laid. The bill for these changes comes to more than six million dollars. One of the largest of the diverted sewers is in the neighborhood of the Pennsylvania Station, at Seventh Avenue and Thirtieth Street. Now that a new subway is coming up Seventh Avenue, this sewer is being rebuilt to give outlet into North River—at a cost of five hundred thousand dollars.

Or consider the fact that while construction is in progress under the street, many gas-mains must be carried over the roadways on trestles. The average cost of doing this is twenty-five hundred dollars; and where larger distribution mains must be handled, the cost runs as high as ten or eleven thousand dollars.

Street-Cars and Wagons Carried on Dry-Land Bridges

Or, again, in accounting for where so many millions must be spent in building subways, consider that the engineers never vacate more than half of the roadway at a time, and that the street-railways overhead and all the stream of vehicles and pedestrians are literally carried, while the digging is in process, upon miles and miles of dry-land bridges. They are the longest bridges in the world, and bear as much traffic as the busiest in the world.

Then, too, hundreds of buildings must be shored up, for many of them are not built upon the solid rock; and rotten strata of treacherous stone must be braced to prevent slides. In a number of instances buildings had to be torn down. The famous old Astor House was one of these. It stood on sand at a corner under which a tube had to pass.

But one of the most ticklish operations of all is a section of new subway in William Street, where the underlying mate-

rial is quicksand. William Street is a narrow winding lane of old downtown New York. It is barely forty feet in width between building fronts, and in the half-mile section where the subway is being dug (from Beekman Street to Pearl) it bears twenty buildings of from seven to twelve stories in height, and ten of from thirteen to twenty stories. When the digging was first proposed, owners of abutting property assessed at forty million dollars protested and carried the case into court. The Public Service Commissioners had so much confidence that the work could be done safely that they assumed responsibility for any damages that might result.

Building on Water

"The conditions encountered are unique," writes John H. Madden, Asst. Division Engineer, "in the number of large and heavy buildings, few of which have foundations to rock or hardpan, and with these exceptions all other foundations are above the subway subgrade and uniformly above water level as well." The subway's floor is, in general, three to five feet below mean low water; and below ground water level the material is swimming sand. "To guard against any possible flow of material into the subway trench, continuous bulkheads, either in the form of rigidly held, tight sheeting or concrete cut-off walls, will be introduced between the underpinning piers so as to form an integral portion of the latter and will be carried to such depth below the subgrade of the subway as to eliminate any tendency of the quicksand to flow under the toe and be released into the excavation." The total estimated cost of the section is two million, two hundred fifty-four thousand, six hundred and seventy dollars, of which six hundred and four thousand, five hundred dollars is for underpinning.

William Street is not the only place where the subway diggers have to be particular about building stanch floors and sidewalls. At Broadway and Canal Street an underground watercourse was encountered and a very heavy floor had to be built to resist the water's upward pressure. Pumps with a capacity of twenty million gallons a day were kept

One of the serious difficulties often met by the engineers. Underground water is seeping into the tunnel near the corner of Broadway and Canal Street so fast that a set of pumps removes twenty million gallons a day from this one spot. The flooring here is reënforced to re[illegible] the upward pressure of the water and quick[illegible]

busy for a while, discharging a volume of water as great as the daily supply required for a city the size of Atlanta. Care had to be taken, meanwhile, not to pump out sand along with the water, or the adjacent buildings would have come tumbling down, just as in a certain engineer's vision of the most effective way of destroying the city of Boston:

An enemy need not bother mustering battleships or waste his time bombarding from afar the intellectual Hub of this land of ours. In time of peace let him have his spies build a big pumping station right in the middle of that city, and at the proper time start drawing indiscriminately from the ground below the water saturating the subsoil. You know a large number of Boston's big buildings rest upon floating foundations. Pump out the water in the supporting quicksand, and down those structures would tumble into the yawning cavities so created. It would be far more effective in its demolition than the projectiles of a hostile fleet!"

Up near the north end of Manhattan Island, at Lexington Avenue and One hundred and Twenty-ninth Street, the subway diggers had to construct another stout waterproof floor when they encountered what evidently was once a swamp.

We mentioned, in passing, the razing of the old Astor House, which was built upon sand. The tunnel which comes up Vesey Street and cuts under the site of the old hotel curves around into Broadway through big cylinders of cast iron.

Underground swamps and watercourses, sand, quicksand, sand mixed with boulders (as in Brooklyn)—all these the diggers encounter and vanquish. But what the subway builders fear most is something different from all of these: a material known to the geologist as Manhattan Schist and to the rest of us as "rotten rock." No material is more treacherous than this, for along with layers of extreme hardness are pockets and seams of disintegrated stuff, some of it so soft that, after it has been exposed a little

Under the old Astor House, which has been torn down because an underground swamp made it extremely hazardous to tunnel beneath the building. The illustration shows an underground dinner of celebration when a section of the iron tubes for one of the subway lines was completed. The arch of the big tubes shows in back of the posts at the left of the picture

while to the air, it can be crumpled in the hand like earth.

When New York built its first subway, the engineers encountered some of this "rotten rock" in Park Avenue near the Grand Central Station. Serious slides resulted; houses caved in. And the builders of the new subways have not come off any more fortunately than their predecessors. Of several cave-ins the most serious recently was one in Seventh Avenue, near Twenty-fourth Street, where seven persons were killed and eighty-five were injured.

Try to conceive, then, how cautiously the engineers must work in building the Lexington Avenue double-decker subway and in tunneling the treacherous rock in the vicinity of Grand Central Station where (as an accompanying illustration tells better than whole pages of description could do) the ground is being honeycombed into five levels — this in the same perilous ground where the engineers first learned how gingerly they must proceed in a locality where the "rotten rock" literally abounds. And today an extra factor of difficulty must be confronted here from the fact that the operation of the present subway cannot be interfered with while the new tubes are being constructed.

Following a blast, a slide of "rotten rock" knocked out the shoring of the wooden bridge which forms the temporary street, and engulfed a loaded street car, a large motor truck, and scores of pedestrians. Spectators said that the structure fell like a house of cards. The maze of gas pipes and electrical conduits added a grave danger, for a spark from the tangled wires would have exploded the leaking gas, and would have added many more names to the list of killed and injured.

On Saturday, of the same week, a section of Broadway fell in, endangering many lives. Fortunately, there were few pedestrians in that section of the street and only one vehicle, a taxicab, so that the casualties were few. But New York's confidence was sadly shaken.

Rebuilding and moving sewers to vacate space required for the new subways. The sewers alone mean an expenditure of from six to seven million dollars. The illustration shows a large tube making a new outlet for the sewer system emptying into the Hudson River. This outlet will cost the city half a million dollars. To the left of the picture is the magnificent new Pennsylvania Terminal

Floating a Sunken Warship with a Bubble of Air

By M. G. Cary

Two great dangers faced the divers on the wrecked gunboat. The surf constantly beat over the ship and made it almost impossible for the divers to work, and numberless man-eating fish were attracted to the scene. The men had to work in large cages for protection

SALVING the Mexican gunboat *Progreso,* sunk by one of the factions opposed to Carranza at Progreso, Yucatan, was interesting because the vessel suffered an injury identical with that which would have been caused had she been torpedoed. What is more, she was converted by compressed air into a huge bubble, so that she was able to make a long voyage under her own steam. The repair, while provisional, was almost permanent. It was a steel patch applied while the ship was still submerged. The plates were of course bolted and not riveted, but the finished job compared favorably with one done in dry dock.

The story of how the gunboat was sunk has some of the amusing elements associated with Latin-American revolutions. When the *Progreso* was sent to Progreso by General Carranza to blockade that port, the wily Yucatecans hatched a plot. For several days the *Progreso* rolled about in big swells. Word was sent out to her captain that the Carranza sympathizers were going to communicate with him and try to send him fresh provisions. In the jail, a real Carranza sympathizer languished. He was made the unwilling tool of the plotters. Deceived into believing that he would be aided to escape, he was taken from jail, put in a boat with provisions, and sent out to the *Progreso.* As he

The ship had been sunk on a bar in the open roadstead, so that the upper works were awash. The surging of the rollers and the undertow made it difficult for the divers to work or to move about

came alongside he was closely questioned. Some of the provisions were taken aboard, among them were a number of bottles of brandy. Perhaps the brandy allayed all suspicions. At all events it was decided to hoist on board a hogshead of lard. This was found to be already slung. Half way on its upward journey it exploded, killing about thirty men, wounding nearly the same number, and incidentally sinking the *Progreso*. The poor fool in the boat (if he really had known what he was doing, his courage would rank with that of Hobson), was taken on the deck of the sinking ship and shot with characteristic Mexican promptness. The *Auxiliar*, an ocean-going tug, happened to be near, and saved the crew from the sinking vessel.

Five months later a New York salvage company was commissioned by the Mexican government to raise the ship. Ask the head of the wrecking expedition how the *Progreso* was salved, and he will answer: "By a board fence, a few lengths of barnyard netting, and a moving-picture screen." In spite of this airy description, the undertaking was fraught with many difficulties and real danger.

Diagram of the hold of the ship, showing the compartment which was filled with compressed air to make the steamer rise on what was practically a bubble

In the first place the surf was heavy. The steamer sent down by the salvage company wallowed about seventeen days before it was possible to start work. The ship had been sunk in the open roadstead, but upon a bar so that the upper works were awash. Before the wreckers could start to raise her it was necessary to seal every opening; glass deadlights, hatches and bulkhead doors had been blown away. The surging of the rollers and the undertow made it hard for the divers to work or to maintain their footing. Even at low tide the obstacles were formidable, for the surf broke about their heads, and the heavy diving suits hampered them because they were not completely submerged.

Cages Saved the Divers from Sharks

Man-eating sharks added to the hazards of the work; for they were attracted by the noise of hammering, and had to be fought off many times. Even more savage than the man-eating sharks was a

peculiar fish with a cod-like head, called *tinteraro* by the natives. Finally the engineer hit upon the plan of caging his men. Uprights were placed on the four corners of the weighted scaffolds upon which the divers stood, and wire netting was run around the three sides. The *tinteraros* would make a rush for the men, but stubbed their noses against the netting. Men were always on duty with pikes to assist if the cage should give way. After nightfall the fish were attracted by hundreds, and it was feared that the combined weight of many of them would break the netting. Fortunately, it held until the operations were

Before the wreckers could start to raise the sunken steamer it was necessary to seal every opening

completed. cofferdam was erected on deck to bring the space to the same height and to facilitate draining the sunken body of the ship. The cofferdam is the above-mentioned "board fence," and the motion-picture screen was an eighteen by eighteen-foot canvas used inside the hull to close the wound. When all the hatches and deck were thoroughly sealed compressed air was turned into the hold, and the water receded as the canvas was put in place. After only four days of work the craft was towed toward the shore and beached. There the job was completed.

The steel patches were put on when the rent was still below the surface of the water, but where the surf could not harm her. A template was made to lay out the plating, i. e., a full-size pattern to show the exact size and shape of the hole and the location of any existing rivet-holes in the plating which might still serve to attach the new plates. The plating required was then laid out and drilled on deck.

Meanwhile the sand hogs, working in the compressed air, had driven out the rivets in the plating of the ship, where the holes would serve for the new plates. At certain points they drilled new holes, putting a wooden plug in each. The steel patch was then lowered section by section, by a derrick. Starting at the top, these sections were bolted in place over the rent. One by one the bolts were

Lowering the plate into position so as to cover the vent in the side of the ship, made by the explosion. This was done under the direction of the divers by the derrick on the ship's deck. The divers placed it in position and set the bolts, which were fastened on the inside with nuts

put in from the outside by the divers. As the sand-hogs on the inside removed the wooden plugs from the rivet holes, they also put in the nuts and bolts. In the vicinity of the injury, the frames of the ship were entirely destroyed, and they were supplanted by a new structure of heavy timbers. To make all this bolting tight, gaskets of red lead and lamp wick were used. Also, due to irregular contour of the hull plating, in many places it was necessary to fill in with concrete. Once before this method had been utilized, and by the same man, Mr. W. W. Wotherspoon, and that was when the *Royal George* went down in the St. Lawrence River.

Thus patched and plugged, the *Progreso* was finally pumped dry. She was then able to make a sea voyage to Vera Cruz under her own steam. After an examination it was decided that the patches would be allowed to remain as they had been placed, until a slight amount of work could be done to put her into excellent condition while in a New York drydock.

The *Progreso* is a vessel of fifteen hundred and sixty-five tons displacement, measures two hundred and thirty feet in length by thirty-four foot beam, has engines of 1,380 horsepower, and mounts four-inch guns.

The method by which the *Progreso* was raised is substantially the same in principle as that used in driving tunnels under the bed of a river. When the tunnels under the Hudson River were constructed, a "shield" was driven forward by hydraulic jacks. The men who dug and blasted the earth and rock encountered by the shield passed through air-locks; in other words, chambers in which air was forced at such high pressure that the river water was held back and prevented from inundating the workmen. Some conception of this air pressure may be obtained when it is considered that during the construction of the Pennsylvania railway tunnel under the East River a man was actually blown up through the mud of the river, arriving at the surface none the worse for his experience.

It is evident that a kind of air-lock was created in the forward hold of the *Progreso* and air at such high pressure was forced in that the sea water could not push its way in.

After the holes in the hull of the steamer had been patched with sheets of steel, and the forward compartments filled with compressed air, the powerful salvage pumps were started, and the vessel was quickly pumped dry

When the "Progreso" was pumped dry, she was able to steam to Vera Cruz, where she was dry-docked and thoroughly examined

Spending Money by Machinery

By Herbert Francis Sherwood

THERE were no commercial typewriters in Abraham Lincoln's day. The great President often wrote his letters himself. Even with the invention of the time and labor-saving typewriter, there are some tasks in writing which a great man, like the president of a corporation,

One of New York's new pay checks which are printed, filled in, and signed by machinery

could not well leave to subordinates and which were impossible of accomplishment on a machine. Such are the signing of checks and the signing of stock certificates and bonds. The average executive accustomed to the signing of papers, cannot, without fatigue, attach his name to more than twenty-five hundred in a day. In these times, when governments and corporations issue bonds representing millions upon millions of dollars, and have payrolls carrying thousands upon thousands of names, the task of signing a name in some cases has become an indescribable drudgery. Yet it must be done by responsible persons whose time is especially valuable.

One of the greatest corporations in the world is the municipality of New York. It has more than ninety thousand employees receiving more than one hundred and five million dollars in wages and salaries in the course of a year. In 1915 the finance department of this corporation introduced a method of filling out pay checks and signing them by machinery, and thus saved seventy-five per cent in cost, and accomplished work formerly requiring more than sixtyoffice-holders

The electric machine which fills in the checks with the name and amount at the rate of seventy-five hundred an hour or about twenty per second

Ten fountain pens obey the impulses of the master pen in the operator's hand, and one man can sign twenty thousand checks a day

A machine for numbering and dating checks. The checks are carried forward in a vertical position by means of long belts

For each employee there is a type plate bearing his name. These plates are placed in a machine which can be operated by a clerk receiving $540 a year. The individual checks are printed with names and appropriate amounts at the rate of seventy-five hundred an hour. The machine is almost human. It stops automatically when the supply of check blanks is exhausted, or the reservoir of name-plates has been emptied.

The checks are numbered and dated in a container whose principle of operation is that of the machine used in cancelling stamps on letters in post offices. In order to make the checks valid, of course, they must be signed. This is done on a machine so designed that ten will receive the signature simultaneously. The penholder, which traces the signatures when grasped in the hand of the deputy paymaster authorized to do the work, rests on a ball bearing and is connected with ten fountain pens. With this device, a novice can trace twenty thousand signatures in a day without fatigue.

The Greatest Oil Well Fire Ever Seen

The flames, covering an area of more than a city block, burned in the seepage surrounding the well, but from under the concrete cap twenty-five thousand barrels of oil were drawn off every day

A Fire that Burned Four Months

By A. G. Fasbinder

DURING a violent thunder storm a bolt of lightning struck the oil-soaked ground near the Potrero del Llano No. 4 oil well near Tampico, Mexico, the greatest oil well in the world. For more than four months from that date, August fourteenth, 1914, the resulting conflagration resisted all efforts to subdue it. The flames, covering an area of more than a city block, swept over the mouth of the great well, but thanks to the concrete cap covering the orifice, the main body of oil did not ignite.

Upon the first outbreak of the flames, it was thought that the main well was doomed, as well as a great lake of oil containing nearly two million barrels, which was situated nearby. Twenty-five hundred men were summoned to the work of fighting the flames, and apparatus which had been successfully used at other fires of the same nature was brought to the spot. This great force of workmen labored ceaselessly day and night until the fire was conquered, four months later.

The first precaution against the spread of the flames was the erection of a retaining wall of sand and dirt

The fire mounted hundreds of feet into the air, and at night the huge red canopy over the sky drew thousands of spectators to the scene

A Parapet of Sand to Check the Flames

The first precaution against the spread of the flames was the erection of a retaining wall of sand and dirt which completely surrounded the burning area. The earth itself seemed ablaze, for the oil continued to seep through the soaked ground and furnished new fuel for the flames. Twenty-five hundred men and thousands of dollars worth of equipment were employed during the four months

The battery of fifty-three steam boilers, which pumped immense clouds of steam in a vain endeavor to smother the seething flames

which completely encircled the burning area. The earth itself seemed ablaze for the oil continued to seep through the soaked ground and furnished new fuel for the flames. The fire mounted hundreds of feet into the air, and at night a red canopy covered the sky, visible for many miles. Thousands of spectators watched the work.

A great battery of steam boilers arrived at the spot and pipes were led to the fire. The laborers worked under continuous streams of water from fire hose, for the heat was so great that without soaking themselves in water, their clothing would have burst into flames. Those playing the streams upon the workers had to direct the hose while crouching behind shields to protect themselves from the heat.

When the steam pipes were laid, the battery of boilers was fired up, and clouds of steam descended upon the fire. The effort was vain, for the area of the flames was too great for the steam to cover in order to smother the blaze. More boilers arrived until forty-three were coupled to the steam-pipes. These had no effect, however, so this method was temporarily abandoned.

A shaft was sunk into the ground, and it was hoped to fight the fire through this shaft with the aid of chemicals. This, too, proved unavailing. Spur tracks were laid from the main roalroad lines in order to rush materials more quickly to the scene. Experts were summoned from other mining and oil properties to aid in the work.

Weeks lengthened into months, and still the fire burned fiercely. Much to the surprise of experts the great well, although in the center of the conflagration, did not add its huge flow of oil to the blaze. The concrete cap withstood the intense heat and protected the main quantity of oil. One of the most remarkable features of the fire was the fact that during the time that the fire was burning, the managers were able to draw twenty-five barrels of oil daily from the well through the main flow line from the gate valve, which was well protected by concrete.

The mass of equipment that was brought to subdue the fire was truly enormous. During the four and one-half months that the fire raged, there were used forty-nine boilers of approximately fifty horsepower, twenty steam pumps, three air compressors, two centrifugal pumps, quantities of railroad tracks and ties, road building materials, tens of thousands of feet of steam pipes, etc., all of which took about three thousand men to install.

After attempting nearly every known method of subduing the flames, the engineers in charge set the labor-

ers at work gradually pushing the retaining walls in toward the center of the blaze. Because of the intense heat this was done under the greatest difficulty. The circumference of the wall was gradually tightened, thus slowly reducing the area of the blaze.

Pipes were led to the bottom of the blazing area and oil was drawn as fast as possible from the seepage. As it was not fit for commercial use this was pumped to a safe spot nearly five miles distant from the blaze proper and then burned, making in itself a huge conflagration.

Finally during the last part of December, the five walls had been pushed in so far that the blaze was confined to a relatively small area, and everything was made ready for a last effort, greater than all previous attempts. Tons of chemicals were piled near the scene, and thousands of feet of extra steam pipes were laid from the boilers and pumps. This work lasted until about the first of January. In the first days of the new year, the attempt was made. Chemicals were heaped into the fire area and boilers and pumps poured a deluge of water and steam upon the stubborn flames. For hours this frenzied work continued, the result trembling in the balance. At last the ingenuity of man conquered the stubborn forces of nature, and the fire was out.

It seemed almost hopeless to attempt to calculate the damage done by that bolt of lightning. The estimated production of the great well was one hundred and fifty thousand barrels of high grade oil a day, yet for more than four months but twenty-five thousand barrels were drawn. Thousands of dollars were expended upon equipment for the fire fighters, and other thousands went for chemicals which were fed to the flames.

The fire was watched by the greatest interest by the oil trade of the world, who recalled another record-breaking fire which occurred several years ago not far from the Potrero del Llano conflagration. The Dos Bocas gusher, one of the largest in the world at that time, caught fire before being capped. For nearly a year the fire raged, and only subsided when it had consumed all the oil in the fertile pocket which it had tapped. At the present time it produces only salt water and gas.

Pushing in the retaining wall which finally conquered the flames. The heat was so intense that streams of water had to be continually played over the workers, all of them Mexican peons, who are perhaps the most sensitive of human beings to extremes of heat and cold—except in their horn-like nether extremities, which were not affected in this case

A Gas Well Which Wasted $200,000

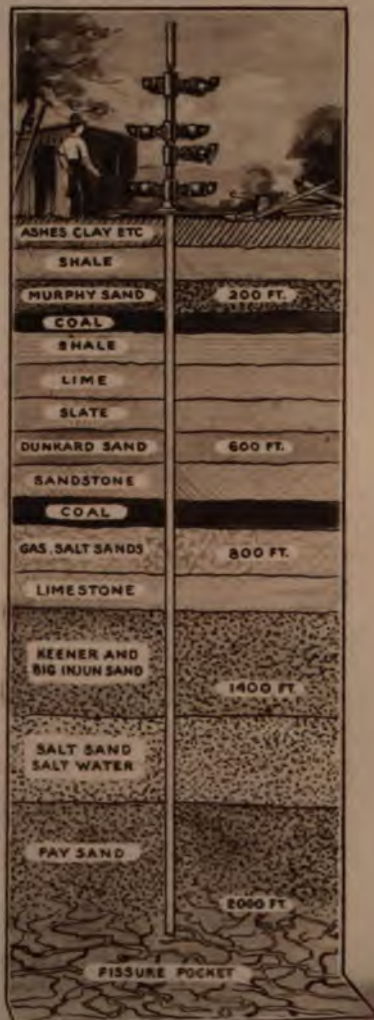
By Harry Knowlson

"BLOWING WILD" with a deafening roar for over a week and wasting upwards of two hundred thousand dollars of natural gas is the record of the largest gas well ever drilled in Pennsylvania. The Spiegel well—for it was named after the owner of the land—is in Versailles Township, near East McKeesport, Pa., that is, in the "Pittsburgh district," a section rich in "pay sand," which has produced several notable gas wells.

This remarkable gas well goes down into Mother Earth as straight as an arrow for two thousand feet. In that region geologists say there is a layer of sand permeated with natural gas. Once an opening is made in the earth's crust, the gas rushes upward with terrific force.

Between six hundred million and eight hundred million cubic feet of natural gas were lost before the well could be capped and the flow controlled. Almost immediately after workmen struck the "pay sand," the gas rushed forth with such destructive force that it demolished the wooden derrick used in connection with the drilling. Several laborers narrowly

The workmen who bored this well sent their drills down two thousand feet through ledge after ledge of earth and rock to tap the fissure pocket full of gas. When the pocket was opened, the gas, confined under those two thousand feet of earth and rock, burst out to the surface, demolishing the derrick and nearly killing the workmen. Over six hundred million cubic feet of gas escaped before the cap was put on and its stop-cocks closed. The cap was of heavy steel, with six valves, all of which were of course left open until the cap was in place, when they were closed. The loss of gas before the process was complete was estimated at $200,000. Great care had to be exercised during the week that the gas escaped unchecked. No lighted matches or other flames were permitted within a great distance of the well. The family living near by were obliged to forego cooking and had to go to bed without light



escaped being killed. Thereafter, for more than a week, the flow of gas continued unabated in quantity and pressure.

This gigantic "gasser" was capped eventually with a long piece of steel tubing, larger in diameter than that in the

The gas blew off at a pressure of one hundred feet per square inch three feet above the outlet

well, and having six valves on the sides and another on top. Of course these valves were left open while the tubing was being placed in position and made secure to the casing in the well, to which it was attached by threads. One at a time, the valves were closed until a pipe was fastened to each to carry off the gas to a reservoir. As soon as the pipe was attached to a valve that one was opened again, so as to relieve the enormous gas pressure. Thus the entire flow was harnessed and taken away for consumption in the neighboring locality and nearby towns.

After considerable difficulty and several unsuccessful attempts, a venturesome engineer finally succeeded in measuring the flow of gas. When a gage was applied a few days after the well struck "pay sand" and the flow of gas was at its height, it was found that there were one hundred pounds open flow three feet above the outlet. And on this measurement the estimate of seventy-five million to one hundred million cubic feet of gas per day was based. The men on duty continuously suffered severely from earaches because of the terrific noise made by the outrushing gas. Fortunately, there was no electric storm or the well might have caught fire. Had this happened, the blaze could not have been extinguished. While the gas was flowing freely, the Spiegel family, living in a house within thirty yards of the "gasser," had to forego cooking and all went to bed at sunset because they dared not have a light.

The value of the lost gas was estimated at the Pittsburgh rate of thirty cents per one thousand. This means a daily loss of not less than twenty-two thousand, five hundred dollars. The actual value may be more, since higher rates obtain in other cities. Since the well ran for seven days and twenty-one hours before it was checked by capping, the minimum total loss was one hundred and fifty-seven thousand dollars. Others put it at close to two hundred thousand dollars.

Why Can a Fly Walk Upside Down?

YOU have seen a boy use what he calls a "sucker," a round, flat piece of leather which is soaked in water and flattened against a stone so that all the moisture between the stone and the leather is pressed out He picks up a brick with a string attached to the leather. Since there is no air between the leather and the stone the atmosphere presses the leather so firmly against the stone that the stone can be picked up by the leather.

A fly has suckers on his feet which act very much on the same principle. As soon as he puts down a foot he automatically squeezes the air out between it and the surface upon which he is walking. The atmosphere, therefore, presses him against the ceiling or wall.

A Machine That Chews Money

FIVE million dollars a day in worn-out paper money was destroyed by machinery in the Treasury Department, at Washington, during the last fiscal year. Two tons of this redeemed paper, amounting to over three hundred and fifty million bank notes, with a face value of more than a billion and a half dollars, passed through the macerating machinery, new money being issued to take the place of that which was destroyed.

This money, after being sent to the Treasury for redemption, is carefully counted, made into piles, first punched and then cut in half, after which a committee of treasury employees sees that it is chewed up in a machine made for the purpose. It is said that the average life of a one-dollar bill is one year.

The great growth of this work since the days of the Civil War, when paper money was first issued, is indicated by comparison with figures for the fiscal year 1865, when seventy million pieces of redeemed currency were destroyed, of a face value of one hundred and forty-four million, two hundred and nineteen thousand, nine hundred and twenty dollars, which included a large amount of fractional currency.

The chief duty of these treasury employes is to see that all old paper money is thoroughly destroyed

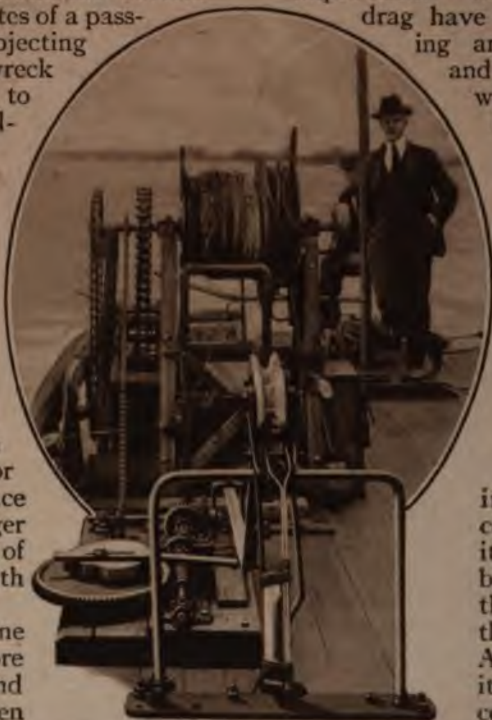
The first step in the destruction of worn-out paper money is to bind the bills solidly and compress them into packages

The government first issued paper money in connection with the Civil War finances, and Secretary Chase's regulations for the destruction of notes unfit for circulation were issued as a result of an act of Congress. In Secretary Chase's time paper money and securities were destroyed by burning. Experience showed that this was not the safest plan in connection with the destruction of distinctive paper, because it is difficult to burn bundles of money, and undestroyed pieces may escape through the chimney. For this reason the act of June 23, 1874, authorized the destruction by maceration. The destruction of these once valuable bits of paper has always been witnessed by a joint committee, appointed for the purpose.

representing depths spaced more or less widely apart, according to the depth and nature of the bottom. If the depths are great and the bottom of sand or mud, the lines and soundings are wide apart. If the depths are not great and the bottom rocky and broken, the soundings are closer together; but there is always a considerable interval between the lines of soundings and between the individual soundings. The soundings represent only the depth over a space of a few inches where the lead touched bottom. It is between the soundings that the danger may lie.

Thus, in the closest survey, large spaces are left, over which the depths are not absolutely known. Jagged pinnacles of rock projecting from the bottom may rip open the plates of a passing vessel. The projecting masts of a sunken wreck may be a menace to the navigator, although not visible above the surface. The lead may slide off a precipitous rock and give no indication of the true depth. A line of soundings has but one dimension, length. The wire-drag line has two dimensions, length and breadth. For every mile of distance dragged every danger in a square mile of area is detected with absolute certainty.

With the lead line their discovery is more or less a chance, and it is difficult and often well nigh impossible, to find a rock or shoal of small extent even when its approximate position is known. The vessel searching for it is as apt to run against the obstruction as to find it by sounding. With the drag such a danger cannot escape. Hence it is the only means of finding all submerged dangers in certain areas. Safety of navigation can be assured by no other means.



The hoisting and measuring equipment on the towing launch

The wire-drag is operated in the following manner: A horizontal wire supported at any desired depth in the water by a system of uprights attached to floats at the surface and held down by weights, is drawn through the water by power boats. Any rock or shoal projecting from the bottom above the effective depth at which the drag is set is caught by the wire. Soundings are then taken over the spot, and its position is located by angles taken to previously determined points on shore. The soundings are afterward plotted and placed upon the charts. In practice the drag has developed into a somewhat complicated mechanism, but in emergencies a simple form of drag may be readily improvised. Modified forms of the drag have been used for finding and removing mines, and for locating sunken wrecks and buoys. It is obviously adapted to many such uses.

The average cost of a wire-drag party is thirty thousand dollars, based on a season's work of from six to eight months. The cost per day is about two hundred and fifty dollars.

Some idea of the importance to this country of surveys of its coasts may be gained by recalling to mind that the coast line of the United States and Alaska, measured along its general trend, exceeds eleven thousand five hundred miles in length. To represent the actual shore line which must be surveyed and which includes all the islands, bays, sounds, and rivers in the tidal belt, these figures reach the large total of ninety-one thousand miles; and to this must be added the shore line of Porto Rico, Guam, Tutuila, the Hawaiian and the Philippine Islands, whose coast line is twelve thousand statute miles.

The Biggest Coal Ship in the World

There Is Nothing Romantic About the "Milazzo." She Is Built for the Brutally Practical Purpose of Carrying Coal. By Means of Twenty Cranes on Her Decks 14,000 Tons of Coal Can Be Unloaded in Forty-eight Hours. Shovels Are Unnecessary on the "Milazzo"

LOOK at the "Milazzo" and watch her unload 14,000 long tons of coal and 4,500 tons of oil, and you say at once: "An American designed her—she is practical." In truth, there is nothing quite like her in the whole world, as ships go. On the other hand, she was designed not by an American, but by an Italian, Captain Emilio Menada, who has earned a reputation for himself as an inventor of transporting machinery.

The "Milazzo" was built to handle bulk cargoes, such as grain and coal—built, moreover, to handle them with the least possible human effort. Accordingly, she is simply an engine-driven hull and a mass of elevators and chutes.

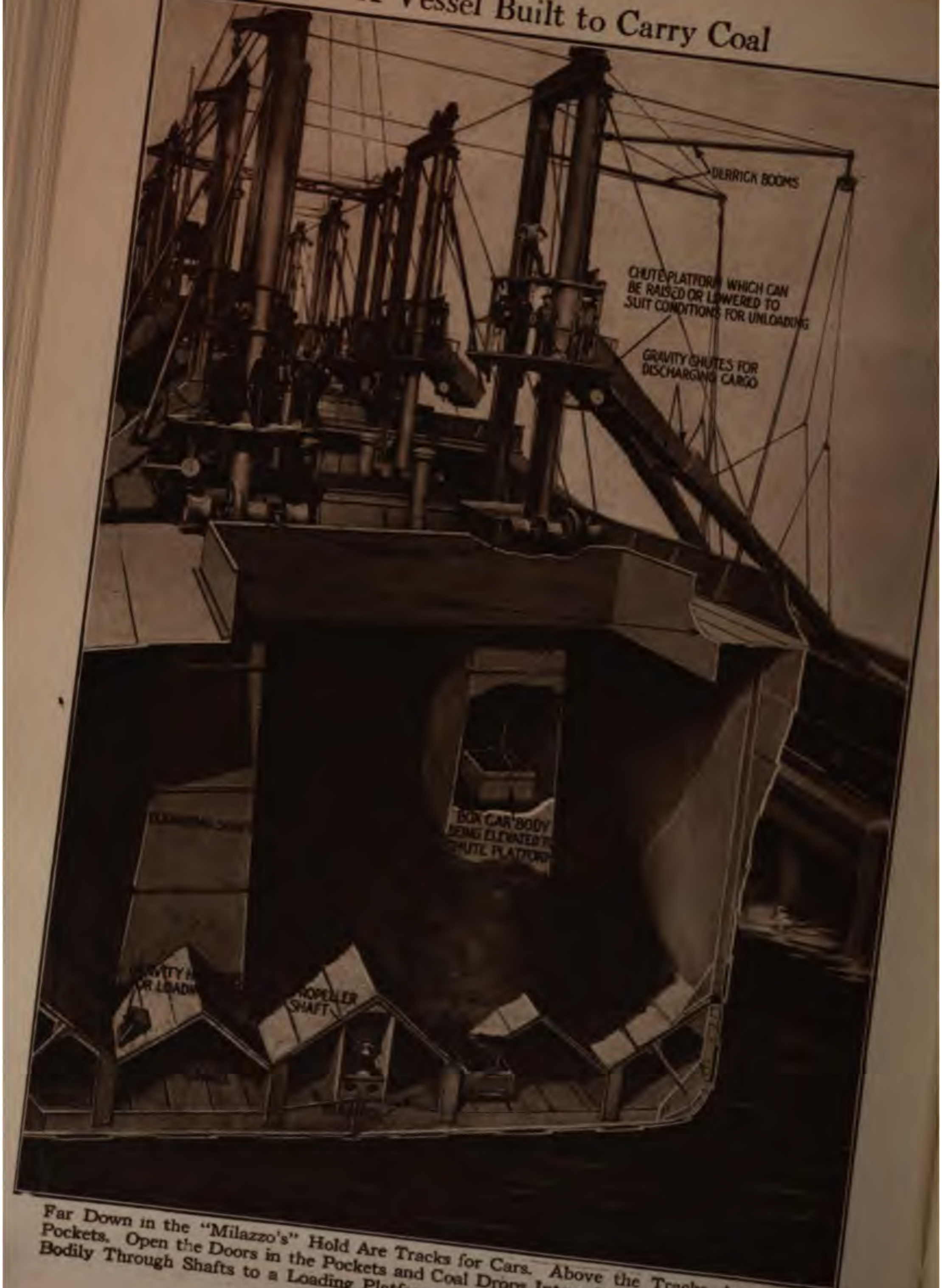
Eight water-tight bulkheads, extending to the main deck, divide the hull of the "Milazzo" into nine compartments. The central compartment contains the engines and boiler fuel. Salt water ballast is carried in the extreme forward and extreme after compartments. That leaves six compartments for the coal.

If you will study the sectional view of the "Milazzo," which appears on the opposite page, you will see that the compartments are merely coal-pockets, similar to those built on wharves. Beneath the coal-pockets, little cars run on rails. When doors, cut in the slanting planes forming the bottoms of the coal pockets, are opened, the coal runs down into these cars by its own weight. When a car is full, it is lifted bodily through vertical elevating shafts up to the main deck to an unloading platform, adjustable in height. Then it is tilted, and the coal runs into chutes. Shovels and grab-buckets are unknown on the "Milazzo."

The 4,500 tons of oil are carried in side tanks forming a double bottom.

With her gross tonnage of 11,477, the "Milazzo" is the largest steamer thus far built for cargo carrying. She is four hundred and ninety-two feet long and draws twenty-six feet of water. Her displacement is 20,040 tons.

A Vessel Built to Carry Coal



Far Down in the "Milazzo's" Hold Are Tracks for Cars. Above the Tracks Are Coal Pockets. Open the Doors in the Pockets and Coal Drops Into a Car. The Car Is Raised Bodily Through Shafts to a Loading Platform, and the Coal Shot Into Cars or Lighters

Boring by Photography

Keeping a Deep Hole Straight

Applying the photographing device to a deep bore to determine whether it is straight or not. The sensitized photographic paper is at the extreme bottom of the device

IN ALL deep borings the diamond drill deviates considerably from its starting direction, and it is sometimes very desirable to obtain a survey of the hole. The device here shown, which is the invention of Charles B. Galvin, of Cornwall-on-Hudson, New York, consists of a steel tube, ranging from fifteen to thirty feet long, with means for indicating and recording any departure of its axis from a straight line. A geometrical straight line, tangent to the curving axis of the hole, is established by the projection upon a disk of sensitized photographic paper of the image of cross-hairs etched on clear glass. Thus, if the hole is perfectly straight the image of the center of the cross-hairs will coincide with the center of the paper disk, and if not, the distance from the image of the center of the cross-hairs to the center of the disk represents the amount of deviation or rate of curvature of the hole.

The vertical and horizontal directions are established on the paper prints by means of the image of a weight, which may be either a plumb-bob or a ball, free to roll to the lowest point immediately in front of the paper. A diameter drawn through the center of the paper and the center of the print of the ball or axis of the bob indicates the vertical and the one at right angles to this, the horizontal. To these lines the lateral and vertical deviations respectively are referred.

Above: A photograph which represents the amount of deviation or rate of curvature of the hole. At left: The location and arrangement of the photographing device. The lamp is at one end of the tube and the photographic paper at the other

A source of light, which may be a one or two-candlepower battery lamp, current for which is supplied from the surface via the cable, is situated in the focus of a condenser-lens. A well-defined image of the cross-hairs is thus projected on to the paper disk at the other end of the tube, by means of the objective lens which is interposed at the proper focal distance between the cross-hairs and the paper. The distance from the cross-hairs to the objective would usually be from two and a half to three and a half or four feet and from the objective to the paper from twelve to twenty-five or thirty feet.

New York's Submarine Subway and How It Was Built

By Howard B. Gates

The author of this article is a Civil Engineer, who is connected with the Public Service Commission of New York city. His official duties were such that he was closely identified with the daring work that he so interestingly describes. Obviously, he writes from first-hand knowledge.—EDITOR.

A TWENTY-story building literally grows out of the ground over night; subways are built beneath our most congested streets and under rivers and we scarcely know they are there until they are ready for operation; our water supply is siphoned under rivers at great depths and runs through the very bowels of the earth in arteries hundreds of miles in length for our convenient use at faucet and hydrant; bridges spring from the opposite banks of our rivers and meet in the center within a fraction of an inch and we talk with our friends across the ocean and continent with perfect ease and understanding. Not only to the lay mind but to the technically trained as well, do these achievements become a source of wonder, the former accepting the result as sufficiently marvelous in itself, while the latter appreciating the underlying principles of science and laws of nature which contribute to their success, wonders at the ingenuity of their application. One of the most recent examples of these marvels of engineering is the "submarine" subway or Harlem River tubes built beneath the Harlem River to form the connecting link between the Boroughs of Manhattan and the Bronx subway systems now nearing completion.

The Harlem River at the point of this crossing is six hundred feet wide and varies in depth from twenty to twenty-six feet. In accordance with the requirements of the Secretary of War, the top of the structure was fixed at a depth which placed it an average of seven feet below the river bottom and made the lowest point in the structure about fifty-seven feet below water. To start the construction at the bulkhead lines was not practicable; hence the tubes were projected landwards, so that the total length of this special construction was one thousand and eighty feet.

The Four Tubes Floated Like Boats

Briefly, the method consisted in assembling the steel shell or form of the four tubes, in sections about two hundred and twenty feet in length upon timber supports above the water. With the ends sealed or partially closed, a section was launched and floated as a boat. Towing it to and anchoring it above its designed location, its tubes were filled with water under positive and accessible controls and gradually lowered into a previously dredged and prepared trench. As each section was lowered in turn, it was attached to the end of the previously placed section and encased in concrete. When all of the sections had been lowered and properly encased, with their ends closed by watertight walls or bulkheads, the water by which they had been sunk was pumped out, and a reinforced concrete lining was placed inside the steel shell to complete the structure.

The steel portion of the structure consists of four parallel tubes bolted together, with flat sides on their interior walls. Between the tubes are vertical diaphragm plates which are placed at intervals perpendicularly to the direction of the tracks and which extend to the rectangular limits of the structure.

Digging Trench for the Tubes in the Bottom of the River

The safe submerging of this light steel form and the temporary control and final location of it, comprise the most spectacular part of this great scheme. The trench into which the subway was to be located was formed by a "clam-shell"

dredge. While the trench was being prepared, the structural steel tubes were in process of building over a slip about a mile away.

In launching each section nine flat-decked boats similar to canal barges, were uniformly distributed beneath the structure at low tide. As the tide rose the huge steel form was lifted clear of its supports; then tugs readily towed it out of the slip. Small valves in the bottom of these boats were simultaneously opened, the section slowly settling down into the water until it floated on its own surfaces as a boat. The flat boats were ballasted with stone to overcome the buoyancy of the wood of which they were constructed and were readily pulled from beneath the structure. After they had been pumped out, they were available for use on the next section.

The flotation of the structure was made possible by the watertight wooden bulkheads which completely closed the ends of the outside tubes and the lower half of the ends of the center tubes. These bulkheads and tubes presented something of the appearance of four large submarines tied together, their ends cut off and boarded up. As the same essential principles are involved in their submersion, they might be termed, the "Subway Submarines." Their weight or displacement when entirely equipped was about seven hundred and fifty tons.

How the Tubes were Sunk

It is evident that, if the tubes are to be submerged, an enormous weight must be added to overcome the buoyancy that causes them to float. The admission of water suggests itself; but the scientist points out that this is a practical impossibility. Certainly it is a grave risk, to attempt to control and adjust the amount of water in so large a structure, especially where any tendency toward unequal settlement might cause the water to flow to the lowest points, and eventually plunge the whole structure to the bottom a hopeless wreck. It is a well-known principle in physics that the resulting buoyancy-effect of a floating body (in other words, the weight which the floating body will carry and remain floating) is theoretically equal to the weight of a volume of water of the same dimensions as the floating body, less the actual weight of the body. In the light of that principle the use of the four steel air cylinders illustrated in place upon the top of the tubes is at once apparent; they furnish the necessary suspension while the tubes are being filled with water.

These cylinders, of light steel plate, were divided into three compartments (a small center one about fifteen feet long and two end ones about twenty-six feet long). Each compartment was fitted with separate valves for the admission of water and for the application of air pressure by which the water could be removed entirely from the cylinders, or from any compartment, or adjusted to any desired refinement. The cylinders had a combined floating effect seventy-six tons greater than the structure when submerged. Hence it was necessary to let in but nineteen tons of water to each of the cylinders to overcome their tendency to float. With the buoyancy-cylinders in place and four long steel location masts erected and carefully plumbed so that they were exactly over the center line at each end of the outer tubes, the section was ready to be towed into position. Approaching the site, the scene presented was essentially that shown at the extreme right in the illustration.

Filling the Tubes with Water to Sink Them

In order to fill the outside tubes with water (the first operation in lowering a section), twelve-inch submerged valves in each of the end bulkheads were opened simultaneously. With the excess floating effect of the buoyancy cylinders in mind, it will be appreciated that it was relatively unimportant how fast the tubes filled with water as long as they maintained an even keel. Slowly the section settled, as it filled with water, until it became submerged. Gradually it transferred its weight to the buoyancy cylinders and pulled them down into the water until only about two feet six inches of the cylinders were visible, a condition which followed shortly after that shown in the insert at the lower right-hand corner of the double-page illustration. Workmen standing u-

The four tubes of the new subway under the Harlem river in New York city are being put in place by floating them to a point above their destined position. The sections are then released from the barges which are carrying them half submerged and are dropped into place. Once in the trench which has been dug in the river bottom, concrete is sent down through

The great tunnel sections seem to float in the water as easily as though they were of wood. Four sections, when floated to their positions, weighed seven hundred and fifty tons

A section ready to be launched for towing to its resting place. Note the great size by comparison with the man

pipes to embed the tube sections solidly in the rock and to join the sections, one to the other. The work is done by divers where the elaborate mechanical system is inadequate, and at last compressed air forces the water out and the final joining is completed. This method requires less time and is less expensive than the use of a driving-shield.

each of the cylinders next simultaneously turned wheels which opened a three-inch water-valve in the bottom of the center compartment of each cyliner and by carefully observing the rate at which the cylinders became submerged and testing the subsequent load transferred to the derrick, the nineteen tons of water to overcome the buoyancy was admitted, filling the center compartment to about one-half its capacity. Then just enough more was let in to hold the section in position when lowered, against the action of the tidal currents in the river. This total excess load never amounted to more than a few tons, which the derricks readily sustained. The section was lowered, until one of the diaphragms at or near each end, rested upon temporary timber frames, in the shape of an inverted "U." By means of the location cables attached to the ends and sides, the section could be shifted north or south, east or west until the masts (which projected about ten feet above the water) indicated that the structure was in proper position. The control over this large steel structure was very complete; the section could be raised or lowered, shifted at will, or could even have been brought to the surface again if conditions had made it necessary.

How the Sunk Tubes Were Joined

Each section after the first, had a positive anchorage to the section previously placed; the ends were brought into perfect alinement by means of steel pins mounted on the end of one section, and guided into tapered holes in castings mounted in the same relative position on the other section. As the two sections were drawn together, the pins were started into the tapered holes and served to guide the ends to a positive junction, then a diver bolted them together. The complete operation from the time of opening the valves to admit the water to fill the tubes, to their final anchoring, required but three hours.

As soon as a section was placed, preparations were made to deposit the encasing concrete, the weight of which was necessary to keep the tubes from coming to the surface when their buoyancy would be restored in the unwatering, and the strength of which concrete, together with the reinforcing effect and waterproofing qualities of the steelwork, was to provide a safe working-chamber for the completion of the subway structure. The section, as far as described, might be considered to be a large box sunk in the bottom of the river, without top or bottom but having sides and ends, and divided by the diaphragms into a series of pockets which could be filled with concrete in any convenient order.

Pouring Concrete Through Pipes

The tubes, being surrounded with water, the problem resolved itself into displacing this water with concrete and without the loss of the cement which would occur in dropping the concrete through even a much less depth of water. This was accomplished by what is technically known as the "tremie" method of depositing which involves the use of long pipes which are kept nearly full of concrete and which are raised a little as the concrete is poured in at the top. A nearly continuous flow is maintained. The concrete gradually displaces the water but does not mix with it. Each pocket required an average of twelve hours for its completion by this method.

When all of the pockets had been filled, except those over which the buoyancy cylinders had been placed, these cylinders having performed their functions, were disconnected by forcing the water out of them; they floated to the surface there to be reclaimed for use on the next section.

With all of the sections in place and encased and with the extreme ends of the series closed by the heavy wooden bulkheads previously mentioned, four small steel shafts or wells attached to the tubes before sinking, were opened and the water pumped out. It was then possible to get inside of these submerged passages beneath the river, assemble the concrete forms and place the lining, thus completing the structure. There were no leaks in the tubes except where some of the bolts in the interior walls had not been tightened sufficiently, and by tightening these bolts, the finished work was, figuratively speaking, "dry as a bone."

Workmen Shot From Tunnel Through the Bed of a River

By Eustace L. Adams

BROOKLYN BRIDGE was jammed with mid-afternoon traffic. On the East River, far underneath the lofty structure, tugs and barges were busy with their endless tasks. Suddenly passengers on the bridge and crews of boats heard a muffled roar, and a geyser shot from the river twenty feet into the air. Dark forms mingled with the water, and a moment later, when the rush of the geyser had died down, three men were seen floating on the surface of the river.

One of these men quickly disappeared from sight. His dead body was later recovered. The other two swam for shore and were rescued. One of them died before he could be taken to the hospital. The other lived. All three men (sand hogs, who had been digging in an atmosphere of compressed air under the river) had been blown from their posts in front of the great steel shield which is boring through the East River bed to the open air. They were shot through twenty-seven feet of river mud, twenty-five feet of water and an additional twenty into the air on top of a geyser of mud and foam.

The first knowledge that the officials at the Brooklyn end of the new subway tube had of the accident was when a number of terrified workmen rushed into the compressed air caisson, clamoring to be let out. Among these was one man who had been a witness of the accident, and from him a coherent story was obtained.

The tunnel in which this strange accident occurred had been pushed out under the river for about three hundred feet, by what is known as the shield method. When engineers commence their underground tunneling, a heavy steel shield is built at the end of the shaft where the men are at work. This shield is pushed forward into the mud or dirt for a distance of two feet by a number of hydraulic rams which are capable of exerting a pressure of five thousand pounds to the square inch. In the shield are a number of doors which allow the workmen, or "sand hogs," to dig away the dirt, stones and mud in front so that the shield may be moved another two feet.

The question naturally arises: What keeps the mud and water from coming into the shield and overwhelming the workmen? A short distance behind the shield is a bulkhead wall, containing air locks. The entire space forward from the airlock is kept filled with compressed air. This air, when maintained at the proper pressure, balances that of the water and keeps it from flowing into the tunnel. If sufficient pressure is exerted by the air-pumps, the water is driven still farther away, and the workmen may work on dry ground, instead of on mud of a molasses-like consistency.

As they excavate in front of the shield, the workmen plank up the opening they have made and remove the planks just before the shield is to be pushed forward. The shoring serves merely to keep loose earth and stones from falling upon the men as they work.

Four men, who were outside the shield,

Three men were blown through twenty-seven feet of river mud, twenty-five feet of water and twenty feet into the air on top of a geyser of mud and foam while engaged in excavating the bed of the East River, New York city, for the building of a new subway. They were working in what is known as a shield, which is pushed forward foot by foot as the workmen progress. Compressed air prevents the water from rushing into the shield. The great pressure of the air forced the three men one after the other through a hole in the river bed. One of the men, the first to be ejected into the river, survived

had just removed some of the shoring when earth began to drop rapidly away from one spot in the top of the tunnel. One of the men seized a bag of cement which is kept for such an emergency and attempted to block up the rapidly growing hole. Suddenly there was a report like a pistol shot. His startled comrades saw the man jerked up out of sight. Then they realized what happened. The man had been blown away like a pea in a pea-shooter. One of the men managed to save himself by clinging to the shield. The other two victims were shot upwards to the surface of the river.

The instant that the work of rescue had been completed, officials began the work of repair. It was found that the accident had been caused by a spot in the bed of the river which had been unable to withstand the air pressure of twenty-four pounds to the square inch that had been maintained in the tunnel. As a result the bottom of the river had blown out like a faulty automobile tire when overcharged with air.

Only once before in the history of tunneling has a workman been shot through the bed of a river and survived. Eleven years ago a "sand hog" was blown through the bed of the East River during the construction of the present subway system. Although severely injured he survived the shock, and by a curious coincidence was working on the tunnel in which the recent accident occurred.

Militia Aero Corps

TWENTY-FOUR states are at present organizing aero corps to be included in their National Guards and Naval Militias.

Climbing Steel Poles with the Aid of Iron Shoes

IT was always an easy matter for a lineman to stick the points of his climbers into the sides of a wooden pole and reach the top with the agility of a squirrel. With the introduction of steel poles for high tension electrical lines, some other climbing help had to be found. A forged steel shoe has been invented, which is neatly strapped over the regular shoe.

Spikes help a lineman to climb a wooden pole, but not a pole of steel. A shoe has been invented which enables a lineman to clamp himself step by step on the steel pole

The toe of the steel pole-climber curves upward. On its tip there are two steel projecting bearings or clamping points, and these points tell the secret of the device. A square steel block, having four sharp corners is placed just beyond the toes of the steel shoe. When dull from use these corners may be substituted one for another.

This special block bears on the outside of the steel pole, and a steel point situated at the end of the climber bears on the opposite side.

The climbers have a clamping action between the block and the point on the edge of the steel pole. This action is accomplished by the pressure of the lineman's weight on the end of the climber. Naturally his weight will come at the right point in climbing the pole. As he raises his foot for the next step, the lifted heel releases the grip of the climber. The steel climbers weigh about as much as the old style grippers used for the wooden poles.

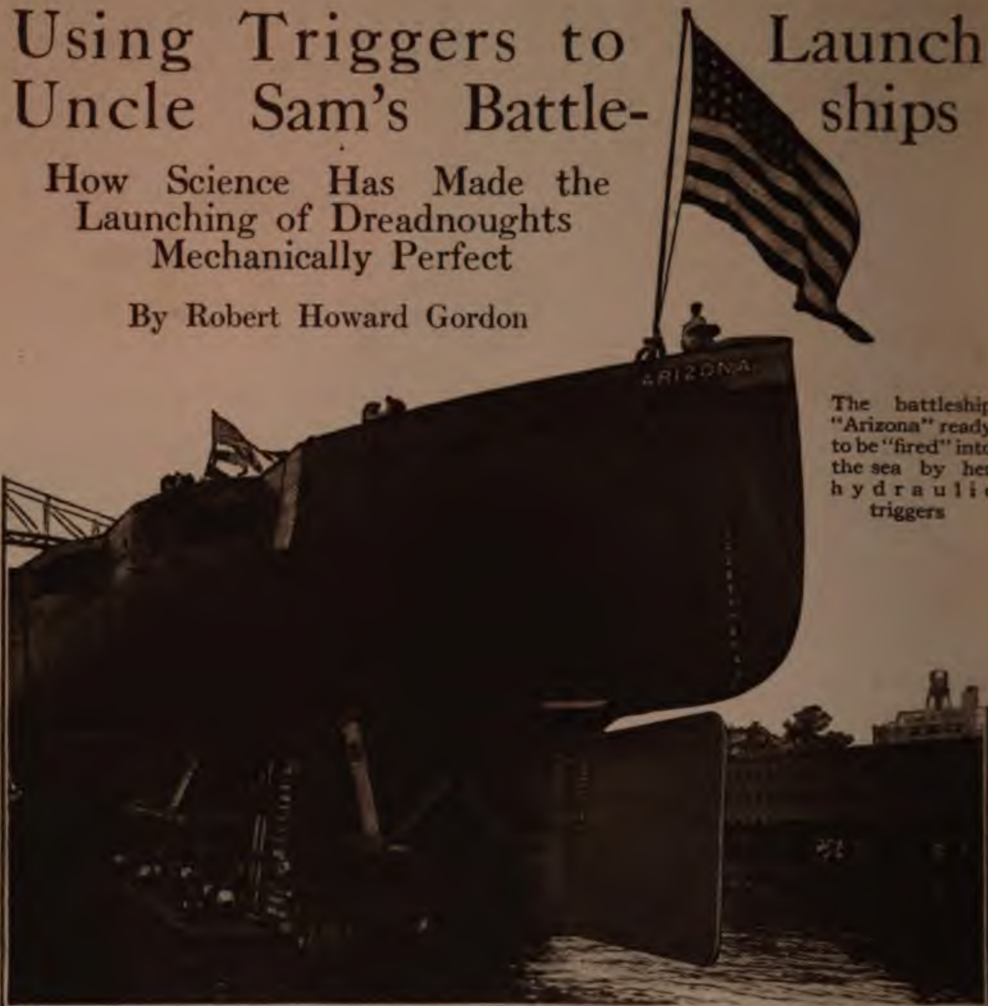
An Invisible Ink

WHEN the juice of an onion or lemon is substituted for ink, no visible effect is made on the paper until heated, when the writing will stand out very plainly.

Using Triggers to Launch Uncle Sam's Battle-ships

How Science Has Made the Launching of Dreadnoughts Mechanically Perfect

By Robert Howard Gordon



The battleship "Arizona" ready to be "fired" into the sea by her hydraulic triggers

THE launching of a great battleship involves the problem of releasing a ship from its ways without straining the shell. In the case of such great super-dreadnoughts as the *New York* and *Arizona*, the great length and enormous weight of steel necessitate unusual care in calculating the points where the strain can be relieved by additional ways. The "ways" are of two kinds, ground ways, which are immovable, and sliding ways, which move with the ship into the water.

Ground ways consist of longitudinal timbers on either side of the keel, placed about midway between the keel and the turn of the bilge or under surface of the vessel. The sliding ways are similar and rest upon the ground ways, with a thick coating of stearin or grease between them, to facilitate the sliding motion of the hull, as shown in Figure 1.

It was thought best in launching the *Arizona* to carry the ways as far forward as possible to gain additional length of sliding ways and consequently reduce the unit pressure. The extreme narrowness of the fore part of the shell necessitated the placing of three steel-plate slings under the ship, extending from side to side and lashed to the ship by heavy, wire rope as shown in Figure 2. The space between the slings and the hull of the boat was then filled with concrete, which gave the ship a temporarily increased width forward. The under portion of the shell, in the wake of the

concrete, was greased with stearin, painted on hot, and the concrete was tied back to the slings.

The supporting structure for the aft portion of a ship must be removed before the launchings can take place (if the

Fig. 1. Section through the fore part of the supporting structure, starboard side looking forward

stern dips into the water first), since the central portion of the hull has so much greater width. About six weeks before the *Arizona* was launched, the aft keel-blocks were removed and tumbling shores substituted. These consisted of blocks rounded off at their top, forward and bottom, after ends. thus allowing them to tumble when the ship started to move down the ways. This arrangement is illustrated in Figure 3.

The actual releasing of the ship was accomplished by means of two hydraulicly-operated triggers, one on either side of the shell and operated together. The trigger, shown in Figure 4, consists of special forged steel, the upper end engaging a cap set in the sliding ways, and the lower end bearing against a piston, sliding in a cylinder fastened to the ground ways. The cylinder contained a thirty per cent mixture of glycerin and water. When the signal was given, a releasing valve was turned,

Fig. 3. Tumbling shores

allowing the glycerin in the hydraulic cylinder to escape. The pressure in the cylinder being removed, the trigger swung on its pivot, disengaging the cap and allowing the ship to move down into the water.

The effectiveness of this arrangement was proved in the launching of both the *New York* and *Arizona*. No appreciable strain was noticed anywhere, though very careful observations were taken.

Fig. 4. The hydraulic trigger itself

Keeping Beverages Fresh

BY a new patent process grape juice, wines or beverages made from fruit juices can be so treated that they will not become turbid and will not form a sediment when stored. Also they are practically freed from any sort of bacteria.

The liquid, under regulated pressure and temperature, is passed through a finely divided mass of some material which will not dissolve or absorb moisture, such as corundum, garnet or quartz, and at the same time subjected to an electric current. If the liquid to be treated is acid, the crushed material it is passed over must be electro-negative; if the liquid is basic or neutral, the material, must be electro-positive. Alternating current is employed.

Fig. 2. View showing steel-plate slings under the narrow fore part of the vessel

The Czar of the Power-House

By the mere pushing of a few buttons on his desk the man who controls the delivery of current from a great power-house can stop all street cars, put out all lights and shut down hundreds of businesses dependent upon the power

THE man who controls the outgoing current from a central power-house is a Czar whose domain may cover all territory within a radius of one hundred to five hundred miles of the station. By the mere pushing of a few buttons on his desk he can stop all street-car systems and every interurban railroad. He can put out every light, cool every electric flatiron, cause mills to shut down—in fact deaden every activity in his territory dependent upon electric power. The men down in the great power plants await his call. At a signal from him they let loose or restrain huge turbines—machines in some cases each capable of putting forth ten or twelve thousand horsepower, more sometimes than half a state uses in all its industrial activities. Outside men patrol the long transmission lines. If trouble develops in any one district an automatic signaling system apprises the dispatcher of the fact, and by means of telephones at his elbow he mobilizes the men. All energies are bent toward making immediate repairs.

If a lightning and rain storm is approaching, a wireless system acquaints him of its coming. Lightning is the dispatcher's principal enemy. Often the wireless system tells of approaching storms, even though the sky be clear.

Only in times of emergency does the load-dispatcher exert his full powers. Huge central stations are often under contract to supply uninterrupted service. Sometimes they incur heavy penalties if contracts are not carried out. The dispatcher is simply a man made in part responsible for the smooth working of the system. When the street cars, elevateds, and subways are taxed to the utmost in carrying home-going crowds, he is the man who has had extra boilers put in service and extra engines started in order to carry the suddenly increased load. So, too, he prepares for the many lights of evening.

The Marvelous Voice Typewriter

Talk to It and It Writes

By Lloyd Darling

CONCEIVE, an ordinary machine resembling the machines in common office use—full of the customary cog-wheels and crooked levers and variegated springs. It might be an adding machine so far as one can judge by external appearances or a dictaphone or a new-fangled cash-register. But——

Speak to it!

It becomes alive. It *hears* you. It vibrates with action. Somewhere inside, typewriter bars go "clickety-click-click." At the top of the machine a sheet of paper unwinds from a roller.

The largest camera in the world, used by Mr. Flowers in experiments for recording rapid sound vibrations

The machine has written down what you have spoken!

If you said "cat" it wrote down "cat". If you said "Dear Sir: Your favor of recent date received and——," as though you were starting out an ordinary, time-worn business letter, it wrote that same thing down.

An odd feature about the machine is that it spells words as they sound and not according to some fat dictionary. Indeed it would have to be a phonetic speller. How else could it distinguish "dough" and "tough?" But if you are considerate, and mindful of its feelings enough to spell out words correctly in cases where it might be likely to err, the machine will very obediently follow you and make the resultant letter strictly orthodox so far as spelling is concerned. It faithfully tries to do its best.

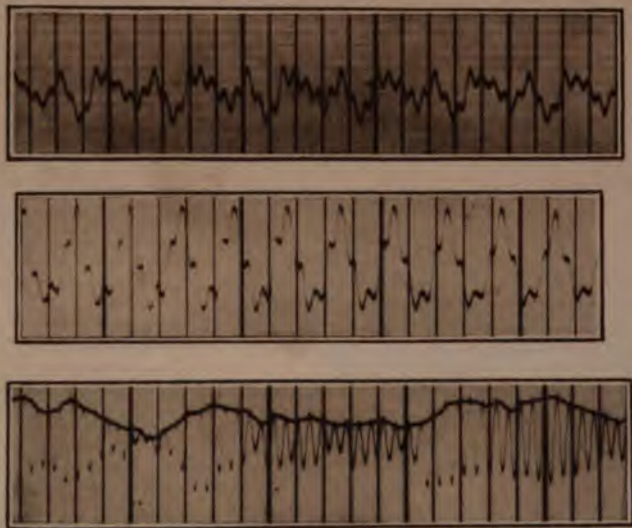
Does the machine think, as well as hear? How else can it perform all these feats if it doesn't reason?

Unfortunately, the machine doesn't think, however much it may appear to approach that desirable attribute. One reason is that at present the machine is brainless. But, even if it had a brain, that organ would be of no use in controlling parts completely separated. Thus far the inventor of this contrivance, Mr. John B. Flowers of Brooklyn, N. Y., has succeeded only in getting the various parts to operate, alone and by themselves—in itself no mean achievement. The machine as we have depicted it is the conception toward which he is working. It opens up a wide vista for the imagination. Think what it means for the office of the future to have an almost human machine at hand to perform the routine drudgery of typewriting and letter-writing!

Unlike most projected inventions of the kind this machine was not conceived as an idle dream. It is based upon sound technical reasoning and researches as

How the Voice Typewriter Works

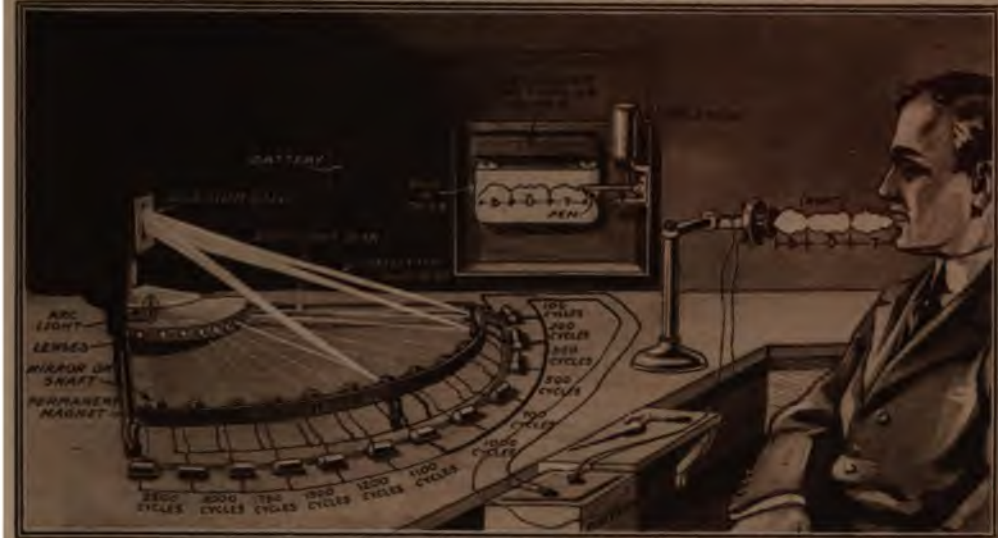
This is the machine used to evolve the natural alphabet. The man at the left is whispering into an acousticon or loud-speaking transmitter, which is attached to a heavy weight, in turn suspended by springs. The inertia of the weight and the resiliency of its spring supports, prevent exterior vibrations of any kind from jarring the extremely sensitive transmitter. Connected with its circuit is a string galvanometer. The whole arrangement is so sensitive that faint whispers readily cause the "string" to vibrate. Light from the arc light throws a shadow of this vibrating string on to the camera at right. A revolving drum carries a strip of photographic film and makes a permanent record of the vibrations. Sample records are given at left, together with an explanation below of what those particular curves signify.

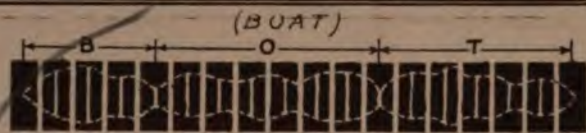


These strange curves are records of the whispered and spoken vowel "U"

The strange curves shown above are records obtained from the apparatus. Upper Curve: Man's voice pronouncing the letter "U" bringing out in striking fashion the fact that any underlying curve is obscured by extra humps due to the peculiar nature of the particular speaker's voice. Middle Curve: Woman's voice pronouncing the same letter "U." Note differences from same letter pronounced by man's voice. Lowermost Curve is obtained when the letter "U" is whispered. Whispering is the most elemental way one can transmit speech, since it does not require use of the vocal cords. Contrast this curve with the two preceding. Note that instead of a series of repeating diagrams peculiar to a particular speaker's voice, a definite undulation or wave-shape now appears. In the two upper curves this underlying wave-shape was blotted out by extra curves or humps known as "higher harmonics" which arose from the use of vocal cords and were different for different men's and women's voices. This underlying wave-shape was none the less present in the two upper curves, because a sound shaped in this precise manner is necessary before the brain recognizes the letter "U" as such. Mr. Flowers' feat consists in recognizing this principle, and in demonstrating it. He whispers the whole alphabet into the transmitter of the apparatus shown above, and secures accurate photographs of the undulations, or "letter patterns" resulting. A complete set of these is shown on Page 68. Mr. Flowers found that it makes no difference who does the whispering; the same wave form for the same letter always results. Scientists recognize this as an immense step in advance, because heretofore men attempting to get at the real nature of speech have always been frustrated because the higher harmonics blurred out the true wave present. They could not deal with whispered speech because no apparatus sensitive enough to record whispered speech existed, and the curves they obtained with spoken speech varied hopelessly with each different speaker's voice.

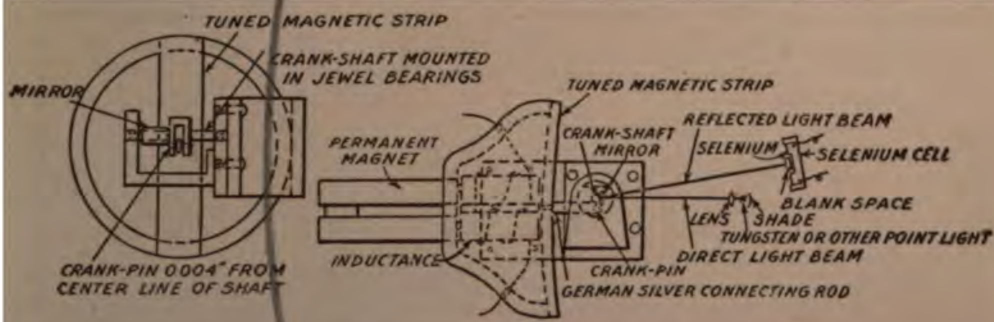
Experimenting with the Phonoscribe





This machine is sometimes referred to as a "phonoscribe." It is designed to take dictation, writing words down on paper in natural characters as fast as spoken. It is of interest here as a forerunner of the voice-operated typewriter. The man at the right is pronouncing the word "boat" as an example. The "a" in boat, being silent, produces no effect on the machine, since it must necessarily spell words phonetically, or as they sound. The "bot" sound vibrations proceed into the transmitter and affect an electric circuit in which are 12 vibrating-mirror mechanisms. Detail of these is given in the figure below. Each mechanism is tuned by the small coils back of it so that it will only respond to vibrations, or cycles, of a certain magnitude. See page 70 for further description.

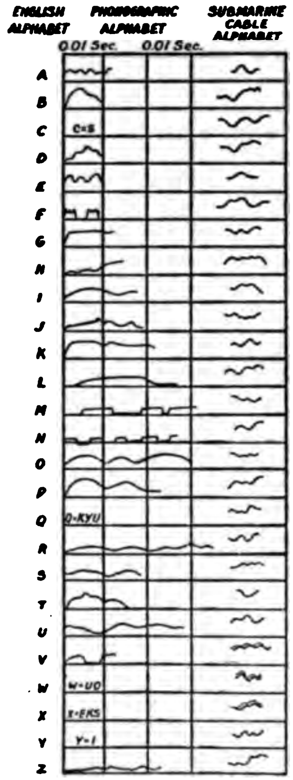
The black rectangles beneath the word "(Boat)" at right make clearer the workings of the selenium cell shown in the picture above. They may be considered a series of instantaneous views of the selenium cell while the light beams are varying in length over its surface. The white strips in the center of each view show how much the light beams happened to be vibrating at each particular instant. The white curves connecting the bottoms and tops of these strips of course have no real existence but were drawn in to show how the light-beam lengths follow the original shape of the word "boat" as sketched in, in front of the man's face. Note also how the curve traced by the solenoid and pen varied directly with the length of these light-beams, tracing the identical curve.



Detail of mirror-moving mechanism. Similar to a telephone receiver in general construction, the tuned magnetic strip taking the place of the usual diaphragm. Attached to the strip is a short lever working a tiny crank-shaft on which a little mirror is mounted. Vibrations from the strip rotate the crank slightly causing the mirror to move through a small arc and throw its beam of light up and down on a selenium cell in the manner shown in the illustration at the top of the page.

well as on experimentation, back of which were the resources of a great typewriter company.

The line of reasoning involved in designing the machine, though somewhat intricate, is exceedingly interesting. Getting any machine at all to respond to such an uncertain and variable director as the human voice, is a task beset with difficulties.



After all, what are spoken words but telegraph signals sent through the air, collected by the ear, and interpreted by your brain? Consider spoken words as sound signals and the voice-operated typewriter becomes possible

Alphabet of natural letter-patterns obtained with the apparatus shown at top of page 66. Note that the natural alphabet is not unlike that now used in submarine-cable telegraphy, though of course the two alphabets have no connection, theoretical or otherwise. The machine shown on page 67 spells out words in this natural alphabet.

This phonetic writing may some day be used in offices as a sort of short-hand system, the dictator talking into a machine similar in principle to that shown on page 67, and the stenographer afterward reading the wavy line from the roll of paper as easily as she would her own notes. The machine with its present design is entirely in laboratory form—interesting however, for the novelty of the idea on which it is based, and because it comes closest to tracing the true wave-form of speech of any machine yet devised.

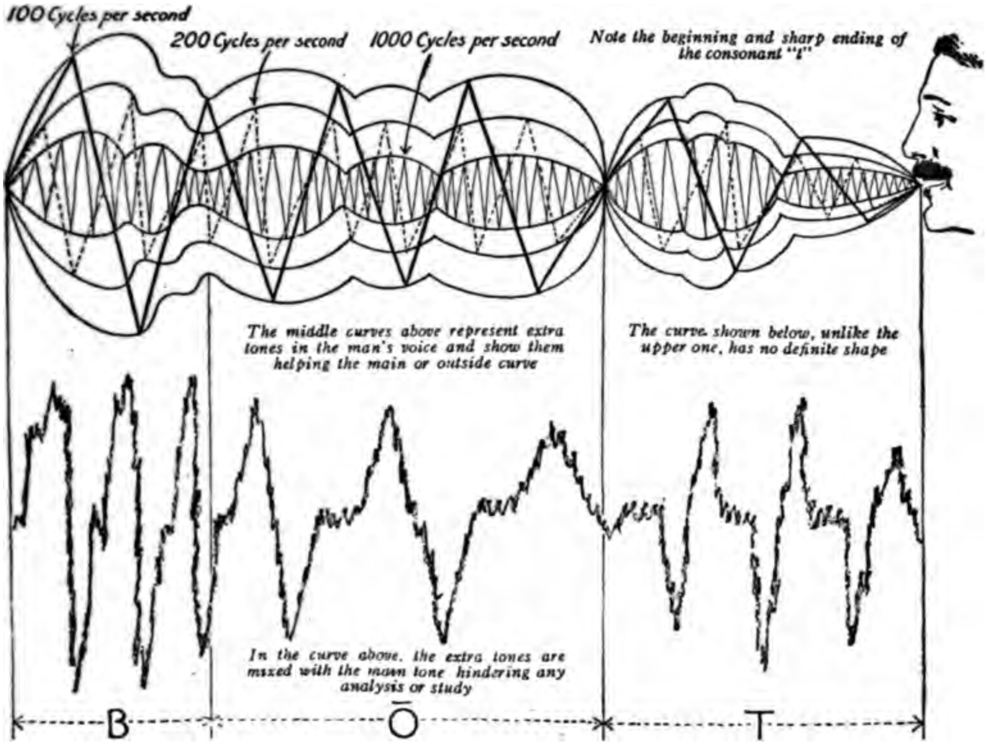
Speech Had First to Be Studied

In a recent paper which he read before the American Institute of Electrical Engineers, the inventor discussed researches lately completed into the true nature of speech, these having a great deal to do with the practical workings of the eventual machine. It was discovered that all speech can be represented by a sort of natural alphabet of sound patterns, which, no matter what the voice may be, always have the same shape. When a *man*, for instance, pronounces a given word he molds air waves in precisely the same way as does a woman. So far as sounds go, a Choctaw Indian is as well provided as a Harvard graduate; the only difference is that the sounds are grouped differently. This is a fundamental law. The mechanism of speech is the same in all of us. Heretofore physicists and workers with speech and sound have been troubled by the fact that they had nothing definite to work with. The consonant letters, when one person spoke them, would appear to have much the same wave shape as vowels enunciated by another speaker. In fact, ever consonants and vowels produced by the same person sometimes seemed to have these indeterminate shapes when the scientists squinted at them through their sound-wave recording machines. Hence the task of ever getting spoken sounds analyzed and classified for study seemed hopeless. Until these letter-sounds were analyzed and classified so that somebody could reason out the real underlying law they obeyed, it was obviously impossible to go go far toward a voice-operated typewriter. One cannot simply say "Write!" to an inanimate collection of levers and expect them to respond.

Why Whispers Were Studied

The instruments which were used in determining the real nature of speech sounds are shown on Page 66. With this apparatus Mr. Flowers dealt only in whispers. Why? Because whispering is the most elemental way one can convey speech. When you whisper you make no use of the vocal cords or other complicated mouth and throat mechanisms. It may be said in passing that one of the principal reasons previous workers with speech sounds failed to get at true sound-wave shapes was that over-tones (extra tones that cause a given voice to have its peculiar and distinctive nature) caused the shape of the main tone or fundamental to be obliterated. Resonant or echoing tones arising in the

What the Word "Boat" Looks Like in Air Waves



The protuberance from the man's mouth in the upper picture is not an unnatural excresence. He is merely pronouncing the word "boat" and molding air waves in the manner shown

This shows detail of the word "boat" as pronounced by the man shown in the illustration at top of page 67. "Boat" spelled phonetically, or as it sounds, is of course "b-ō-t." Hence the curves for "b," "o," and "t," are all that need concern us here and the "a" can be left out of consideration.

These curves look complicated but are really simple and demonstrate most interesting points. In fact, they show us how we really speak, how we really mold air waves in pronouncing a given word. The upper set of curves are in the natural alphabet, as can be verified by comparing their shape with "b," "o," and "t" as given on page 68. The lower curve is the kind the old-time physics teacher would throw on a darkened screen as representing sound vibrations for such a word as "boat." It does represent such sound vibrations but they are in the crude, or unanalyzed state. The upper drawing shows the real multitude of curves whose jarring together, or "fighting," one might call it, caused the lower curve to be jagged and full of humps as it is. Mr. Flowers is the first to evolve this method of making clear the real nature of speech. Note how the machine shown on page 67 actually traces "b-o-t" on paper in natural characters, which ordinarily exist as ephemeral sound waves in front of a speaker, and which are difficult to capture and study.

mouth also aided in this. By dealing with whispers, however, the inventor at once eliminated all complications arising from the use of vocal cords and accompanying resonant vibrations. He could actually determine how it was that one's lips, teeth and tongue shaped letter-sounds and words into air waves.

As the figures on Page 66 explain, his apparatus was so sensitive that all sorts of whispered sounds could be recorded. The lower figure shows three sample records secured with the machine. Hundreds of others were obtained. It was found that each letter of the alphabet had a natural wave form of its own. This was the same no matter who the speaker was. In fact, it was found that these were the wave patterns, which, transmitted by the air, strike the ear and cause the brain to recognize a given letter as such. In other words, the letter patterns secured on photograph paper represented the actual wave shapes which everybody must use in conveying intelligence by means of

speech. It was the first time they had ever been caught and recorded. Man has been molding sound waves into speech with his mouth and lips along lines represented by these curves for thousands of years; but he didn't know he was doing it. The chart on page 68 gives a complete set of these wave patterns. Just how a man molds sound waves into patterns such as these is shown graphically on page 69, the word "boat" serving as an example. "Boat" was chosen because its various letters, as explained in the figure, make use in succession of the lips, tongue, and teeth—three of the principal agents in shaping sounds. It is, therefore, a representative example.

Splitting Up a Spoken Word for the Voice Typewriter

Having discovered that a set of natural letter-patterns exists, the next thing is to make use of them. Accordingly the machine shown on page 67 was designed, and has in part been made to operate. It has been named the "phonoscribe," and is intended to write down speech in natural letter-patterns automatically. As is described in the figure, it makes use of a selenium cell* and a set of special vibrating-mirror mechanisms. These latter are each arranged or "tuned," to care for vibrations only of a certain magnitude. This is necessary, for this machine is intended to deal with spoken speech instead of whispers as did the recording machine shown on page 66. Since spoken speech, as has previously been outlined, is full of troublesome extra tones which obliterate true wave forms, it becomes imperative to have such tuned mechanisms as these to strain out the main or fundamental wave from its incumbrances. As shown in the figure on page 69 the main tone has a frequency, or vibration-rate, of 100 per second. The incumbrances have rates respectively of 200 and 1,000 vibrations per second. The three mirror-mechanisms which handle these rates are shown throwing their united light-beams on to the selenium cell, enlarging and diminishing the width of this light beam in unison, and so cause the cell correspondingly to vary the electric current through the solenoid and recording apparatus shown in the center of the figure. The width of the light beams at any one instant of course depends on how much the mirrors happen to be vibrating, and this in turn is controlled by the amount of current coming from the telephone transmitter at the right. The transmitter naturally shapes this electric current to correspond with the varying sound waves reaching its diaphragm from the speaker's lips. The whole apparatus therefore works in harmony, and a string of natural characters appears on the paper, recording whatever the speaker at the right has said—in this case the word "boat."

This phonoscribe is interesting mainly as a forerunner of the actual voice-operated typewriter itself. It embodies some principles, notably that of the selenium cell and accompanying vibrating-mirror mechanisms, which will be used in the ultimate speech-recording machine itself. But in this latter case of the typewriter, a whole collection of selenium cells will be necessary—one for each key on the machine.

The selenium cells are so distributed that only one letter of the alphabet can affect them. Down inside the voice-operated part of the machine these cells will be erected to receive waves coming from the vibrating mirrors when a person speaks. The selenium cells within the machine are arranged to correspond to the characters of the natural alphabet (see chart of these, page 68). If an ordinary rotating mirror be placed in the path of the light beams coming from the vibrating mirrors, it will automatically "spread out" these beams from the straight line (such as is shown on the selenium cell of the figure on page 67) to their natural wave shape (that shown on page 68)—this on the same principle that physics teachers of old used to "spread out" sound vibrations on a screen, using a revolving mirror. The "spread-out" vibrations are intended to fall each on its own selenium cell in the base of the machine, and because of this falling on the proper selenium cell, to affect the corresponding typewriter key.

*Selenium is a metal the electrical conductivity of which varies directly with the amount of light falling on it at any given moment.

Your Meerschaum Pipe

By Felix J. Koch

Pipes in Various Stages of Construction. Cutting the Meerschaum Is the First Step. Then a Hole Is Drilled in the Embryo Pipe-Head Into Which the Future Bowl of the Pipe—a Plug Worked Up on a Nearby Lathe—Must Fit. When the Pipe Is Mounted On This Part the Shaping Process Is Commenced

MEERSCHAUM pipe-making is one of the most interesting processes of the American mid-west. In normal times, the meerschaum comes from abroad. Just now, that export has stopped, and the pipe-makers of Cincinnati get it from others at home—where-ever it may be bought. It is shipped in white blocks, resembling ivory. But the substance is considerably whiter than the usual elephant-tusk is and very much lighter. In fact, the lightness of a given block of meerschaum is astonishing. Handled for American manufacturers largely through New York commission houses, most of the best meerschaum is brought from Turkey in Europe. It arrives in little chests, or *kasten*, within which each separate piece of the substance is found securely wrapped in cotton. Such meerschaum is paid for by the number of pieces. Curiously enough, the dealers prefer small pieces to large, since it takes an

expert cutter to know how to cut such with minimum amount of waste. Skilled meerschaum-cutters out of a job are not easy to find.

Cutting the meerschaum—the first step in pipe manufacture—is done with an ordinary saw. A good workman can cut the forms for perhaps two dozen pipes from the raw material in a single working-day. As cut, these rough forms are thrown into cold water to soak. In the water they are left until the supply desired is cut up and the man ready to go on with the pipes.

Rudely resembling the ultimate pipe, each form is taken in hand and a hole drilled into the pipe-head. Into this hole—the future "bowl" of the pipe—a plug, on a nearby lathe, must fit. With the embryo pipe mounted on this, "shaping" is begun.

Meerschaum pipes are shaped from the stem end on. Different men require varied types or forms of pipes; though the so-called "Bull Dog" shape and the blunter "Hungarian" pipe, and again, the egg-shaped bowl predominate. The base of the pipe is cut off by hand because it does not fit to the lathe.

That we of to-day should still find use for the rush of the wayside-brook is indeed interesting. For the next step in the process old-fashioned rushes are used—cut into slits and employed for polishing the pipes. Usually the rushes are moistened for such use. They impart a polish which, it appears, cannot be otherwise obtained.

Neatly shaped and polished, your meerschaum pipe must be subjected to still another process. The pipe is boiled in common bee's wax, because no piece of meerchaum in the raw state will "color" as smokers require.

After this boiling the pipes are permitted to cool. Then they are given another polishing—this time with cotton flannel sheets and prepared chalk. Even that does not suffice. There must still go to that pipe a final hand-polishing, done with alcohol.

From the time of starting a pipe until its completion, a half-day's steady labor of the most skilful workmen is required.

A Good Workman Can Cut the Forms of Perhaps Two Dozen Pipes from the Raw Material in a Single Working Day. These Forms Only Rudely Resemble the Ultimate Pipe shape

Pipes when finished are classed, according to the meerschaum of which they are made, into first and second grades. And prices for the simple pipe will run from $3.50 to $10, or even $15 at the factory.

Carved pipes, of course, will range to almost any price; twenty-five dollars is perhaps the least for which one can hope to get a fine pipe. Naturally, the price of the meerschaum has much to do with this.

Meerschaum is not, as so many suppose, a spoil of the sea; but is quarried or dug in Anatolia. The fair grades of the stone are found one hundred feet below ground. The deeper you dig the better is the product. The splendidly carved pipes, of which every pipe lover will have one or two, are almost always a deep mine product.

Good meerschaum pipes, if of the softer stone, should color in a year. Others may take two or three years. There is no better taste with the "colored" pipe; though enthusiastic smokers often delude themselves with the belief that there is.

Fishing in Guiana with the Bow and Arrow

INSTEAD of using nets or the conventional hook and line, the natives of Guiana shoot the fish with bow and arrows. The arrow used is designed especially for this purpose and is about five feet in length, with no feathers. The head, which is barbed, is made from sheet iron and is provided with a socket which is slipped over the end of the shaft by a light, strong line about ten feet long.

When the fish is struck and the barbed point is buried in its flesh the cane shaft floats free and resting upon the surface of the water serves as a buoy to mark the catch, which is hauled in by means of the line attached to the head.

With His Bow and Five-Foot Arrows the Guiana Native Can Shoot and Kill Fish Weighing from Ten to One Hundred Pounds After "Calling" Them Up

Fish weighing from ten to one hundred pounds are caught in this manner. When there are no fish visible or when they are too far beneath the surface to shoot with certainty the natives resort to "calling" the fish. This is accomplished by uttering a low whistling sound and waving the finger tips in a peculiar manner. Surprising as it may seem, the fish often approach the hunter within bow shot when thus called.

But one does not need to go to far-away Guiana to see fish killed by the bow and arrow. Our own Native American Indians are past masters of the trick, and a sojourn with them in one of the western reservations will convince the visitor that shooting fish is one of the Indian's favorite pastimes. An arrow much shorter than that used by the natives of Guiana is used, and no line is attached to the head of the arrow.

The Floating Vegetable Gardens of Mexico

THE Lake of Xochimilco, near the city of Mexico, is nearly covered with floating gardens called chinampas, on which are cultivated vegetables and flowers for the city markets. They are formed of floating masses of water plants covered with soil and secured by poplar stakes. The latter take root and surround the islands with living hedges, which are useful as well as ornamental

Piping Oil to Ships at Sea

A steamship on the other side of the bar plays the part of a hauling locomotive. Flags are used for signaling and an elevated disk designates a station to the ship out at sea

At left: Transporting the pipe-line sections into the ocean by railway

Below: Vessels to be loaded pick up buoy with hose attached and signal a pumping station

GREAT oil regions lie to the west of Tuxpan, which Mexican city, in consequence, has become a most convenient point for exporting oil. However, there are neither docking nor harbor facilities, because of an immense sandbar which effectually prevents ocean-going vessels from approaching the city much nearer than a mile.

To overcome this difficulty, the oil companies devised a novel method of loading oil. Long pipe lines were run out under the sea and over the sandbar. To the outer ends of these lines flexible elbow joints were attached. Nipples on the upturned ends of the elbow joints were provided for the attachment of rubber or other hose, leading from the pipe lines to the surface, their position being plainly indicated by large buoys.

In loading oil, vessels simply ride at anchor in the open roadstead, pick up one of the buoys with hose attached, signal a pumping plant on shore, and take on oil at the rate of one thousand, seven hundred barrels an hour. Even though the vessels roll, the intake of oil is not seriously retarded. Indeed, oil is taken aboard with almost the same

ease as if the vessel were tied to a wharf. Many thousands of barrels of oil are thus shipped from Tuxpan each year.

The success of the first lines at Tuxpan stimulated the installation of many others at, or near the port, until the submarine method of loading oil has become standard in the region. The method by which the pipe lines are laid is no less interesting than their function.

How the Pipe Line Is Laid

A trench is first dug through the sand dunes near the beach, until a smooth, even grade is secured down to tidewater. On this grade short ties are laid back from the beach. On these ties light rails are laid, the gage being less than a foot. On this narrow railway small cars or "dollies" ride. The pipe sections are connected on shore beside this narrow-gage track, lifted upon the "dollies," and thus transported into the ocean. A steamship on the other side of the bar plays the part of hauling locomotive to the dollies, a hauser being employed.

As a rule the lines are made up of 8-inch steel pipe and approximate a mile and a half in length. Frequently a small hoisting-engine has to be installed along the track to aid the steamship at sea in pulling the line. By fastening a cable back of a coupling on the line and running it over one of the drums on the hoisting engine, substantial aid can be given in this work of hauling.

A Fog-Stick Guide for Traffic on the Great Lakes

IN very foggy weather the barges towed by steamers on the Great Lakes are often lost to sight, so that the safety of both steamer and barge is jeopardized. The fog-stick shown in the accompanying illustration was designed to meet this condition. It is sent out from the steamer on the steel towline by means of a pulley or block, and is run up close enough to the barge to be always visible to the man at the forward wheel and to indicate the direction in which the towline is leading and consequently the relative position of the steamer.

The fog-stick is run out from the steamer on a steel towline by means of a pulley

Rope guys hold the fog-stick at the required distance from the bow of the boat and a weight composed of a bag of sand keeps it upright. At night, or whenever the fog is thick enough to warrant it, a lantern is suspended from the pole.

Why the Color of Sea Water Is Blue or Green

WHY is the ocean blue? Because of the reflection of the sky? This accounts for some of the color but it is largely a matter of saltness and density. In the tropics where the intense heat and rapid evaporation cause the water to be much saltier the blue is vivid, while the further one goes toward the poles the greener the hue becomes until it is almost as vivid as the [illegible] azures.

Harnessing the Sun

By Waldemar Kaempffert

In the Sun Power Plant which Mr. Shuman erected at Maadi, near Cairo, Egypt, steam is generated by parabolic mirrors set in a light steel framework so as to throw the sun's rays upon a long trough through which water flows in a shallow stream. Thus steam is generated on the same principle applied in a greenhouse to prevent plants from freezing

IF a boy can burn his name on a wooden bench with nothing but the aid of a convex lens and the sun's rays, why is it not possible to make the sun boil water, generate steam, and drive an engine? It seems absurd to burn coal costing from three dollars to thirty dollars a ton, depending upon your latitude and longitude, when the earth is deluged with heat.

The thought of using solar energy for generating power has occurred to many an engineer. John Ericsson, the inventor of the "Monitor," made more than one attempt to harness the sun. In his mind's eye he saw a desert tract nine thousand miles long and one hundred miles wide, extending from the Northern coast of Africa as far as Mongolia, and great arid regions running from the southwestern part of the United States through Central America and along the coast of South America for a length of a thousand miles, animated with millions of throbbing engines deriving their power from the sun. On a rainless strip eight thousand miles long and one mile wide enough solar heat is wasted, he figured, to drive twenty-two million, three hundred thousand solar engines of one hundred horse-power each, nine hours a day. Why, he asked, why should not upper Egypt derive signal advantage from its fortunate desert location and attain a high social position because of its perpetual sunshine?

For thirteen years Ericsson worked with diligence born of optimism. Between 1865 and 1878 he built no less than seven solar motors. Instead of a lens he employed mirrors, which were fastened on a movable frame and which concentrated the sun's rays on a boiler, when he was driving his engine by steam, and on an air-chamber, when he employed a hot-air engine. Although he

succeeded in developing about one horse-power for every one hundred square feet of reflecting surface he abandoned his plan in disgust. "The scheme is impracticable on account of the great cost of the needed apparatus," he declared. "The fact is that although the heat is obtained for nothing, so extensive, costly and complex is the concentration apparatus that solar steam is many times more costly than steam produced by burning coal."

Even if much water could be boiled by mirrors, enough, let us suppose, to develop a thousand horse-power, it does not necessarily follow that the sun motor will supplant the steam engine. Factory machinery must sometimes be driven at night. How can the solar motor do that? In the desert of Sahara the sun does not shine at midnight.

Evidently the inventor of a solar power plant must design a storage system—a piece of apparatus that can be charged with excess power and tapped at will in sunless periods. Ericsson slaved on this phase of the problem as much as he did on the invention of the engine itself. Yet his results were unsatisfactory. Some of his successors have designed machinery to compress air in strong, steel tanks; some have planned systems in which a dynamo is made to charge a storage-battery; and some have thought of pumping water into a reservoir from which it could subsequently be drawn to turn a water-wheel. Compressed air machinery, storage-batteries, and pumps cost much money, even though the sun's heat may be had for nothing—so much money in fact that a boiler and a steam engine may prove cheaper in the end.

Askance though he might look at a colleague who really believed in substituting sun's heat for coal, an engineer could not deny that Ericsson had none too vividly pictured the possibilities that await the successful inventor in desert lands. After making due allowance for the absorption of the atmosphere, the total energy received by the earth in one day from the sun amounts to about 341,600 million million horse-power—equivalent to about two hundred and thirty million horse-power for every inhabitant.

To obtain these figures some instrument for measuring the sun's heat was obviously employed. Ordinarily solar heat is mercifully radiated and carried away as fast as it is received; otherwise the sea would have boiled away long ago, and every living thing on the earth

The parabolic reflectors which serve to concentrate the sun's heat upon a trough of water at their focus move automatically with the sun. This solar plant is capable of giving an average of fifty horse-power. Were it located farther south, it would yield energy amounting to about sixty-five horse-power, making due allowance for the absorption of the atmosphere

would have been reduced to a mere cinder. If the amount of heat received is to be measured, this radiation must be checked. A heat trap must be designed. One of the earliest instruments made for that purpose was devised by the late Professor Samuel Pierpont Langley, of the Smithsonian Institution, somewhat on the lines of a gardener's greenhouse. His heat trap was simply a box provided with a double glass pane and packed with cotton to reduce loss of heat by radiation.

successful if constructed on the principle of the gardener's greenhouse and Langley's box. Mr. Frank Shuman has given us a type of solar power plant in which a thin film of water is heated in a cast-iron trough surrounded by window glass. So intense is the heat impounded by the double glass that the water is quickly raised to the boiling point (two hundred and twelve degrees Fahrenheit) or very near it.

After the water is brought to about

The water which is heated by the parabolic reflectors is stored in well insulated tanks. A low-pressure steam-engine was designed by Mr. Shuman which would take this hot water and use it to drive a piston even though the pressure gained was only four pounds absolute

The layer of air between the two sheets of glass served as a heat insulator, and the glass itself prevented the heat which entered the box from escaping. On Pike's Peak, where the thermometer recorded fifty-nine degrees Fahrenheit, the temperature in the box rose to two hundred and thirty-five degrees. Had he succeeded in trapping all the heat, which is practically impossible, he might have obtained enough to melt solder. Since Langley's time, experiments conducted by Mr. C. C. Abbott of the Smithsonian Institution have given much better results.

These facts having long been known, it has occurred to more than one inventor that a solar power plant might prove

the boiling point in the trough, it is conveyed to a steel storage-tank in the inventions of Mr. Shuman. That tank is not simply an enlarged covered pot, but a vessel so constructed that as little heat as possible can escape from the water within. Just as we keep ourselves warm in winter by wearing clothes to prevent a too abundant radiation of our bodily warmth, so Mr. Shuman swathes his storage-tanks in an insulating material which keeps the water hot for many hours.

But how can an engine be driven with nothing but hot water? Mr. Shuman performs the feat by the paradox of making the water boil without flame after he has stored it. Thus he generates

steam which can be used in an engine of suitable design. It must not be supposed that he discovered the paradox, nor that he is the first to utilize it in a practical way.

When Tyndall in one of his most brilliant writings defined heat as "a mode of motion," he meant that the infinitesimal molecules of which all matter is composed are in a state of vibration. To understand his definition we must imagine the molecules of all bodies, even of so cold a mass as a block of ice, moving about at a high velocity. As soon as the temperature of the body is raised, its molecules vibrate faster, collide with one another, and are made to move in longer paths. Thus the phenomenon of expansion under the influence of heat is produced. When the temperature is raised still higher, so that the solid melts and becomes a liquid, the molecules move in paths so very much greater that there is less common interference. Lastly, when the liquid is made to boil, many of the molecules are actually thrown off, and strike against the walls of the enclosing vessel, so violent is their movement. The pressure of steam or of any confined gas, then, must be regarded as a phenomenon due entirely to millions and millions of blows struck by millions and millions of invisible infinitesimal molecules. If a thimbleful of boiling water were magnified to the size of a cathedral the steam within it might seem to a gigantic eye like myriads of bullets shot in all directions. Because countless bullets strike the walls of this huge thimble not singly, but at once in very rapid succession the effect of steady pressure is produced. A single finger tap may not even move an open door.. A billion simultaneous finger taps will shut it—shut it, moreover, as if it had been pressed by a hand.

Water was easily pumped for irrigating purposes in Egypt by means of Mr. Shuman's Sun Power Plant

At what temperature the molecules will fly off from a boiling liquid depends entirely on the pressure to which the liquid is subjected. The atmosphere weighs down on all earthly things with a pressure that amounts to about fifteen pounds to the square inch at the level of the sea. If water is heated in the open air at sea level the flying molecules must be able to overcome that pressure; otherwise the water does not boil. The temperature at which they can fly off at sea level, at which water, in other words can boil, is two hundred and twelve degrees Fahrenheit. On the top of a high mountain where the atmosphere presses down with less force because there is less of it, the molecules will fly off much more readily than at the level of the sea, with the result that water will boil much below two hundred and twelve degrees. If it were possible to remove the pressure of the atmosphere at sea level altogether, water could be made to boil at the temperature of an ordinary room without heating it. That feat has actually been accomplished in the laboratory by pumping out the air in the water vessel.

What Mr. Shuman has done, therefore, is to remove part of the atmosphere's pressure from the hot water so that steam may be generated. That steam he supplies to an engine which he has designed for the express purpose of utilizing steam at low pressure. After doing its work the steam is condensed into water and is passed back to the greenhouse-like heater.

Bringing home the harvest. The sack contains turtles, weighing in all over a hundred pounds. They are sold by weight—shells and all

Turtle catching is an art in the practice of which the skilful use of special tools is an essential. The chances are very great that J. S. Bassler, professional turtle-catcher for American restaurants, caught the turtle that made your soup to-day. He does it with a long spear, digging the turtles out of their holes and throwing them into sacks for transportation on his own back to his wagon

Catching Turtles as a Business

DID you ever wonder where the turtle in your soup at the fashionable restaurant came from? Did you know that many of the buttons on your clothes were made from the backs of snapping turtles? In early September, when turtles are house-hunting among the pebbles and worms in the muddy bed of some fresh water creek, preparatory to sleeping away several months of cold winter weather, men are getting ready to wake them up in the middle of their nap by jabbing a steel hook into their backs. The work of hunting turtles, though it begins in the early autumn, continues all through the winter months.

The hunting of turtles has become a specialty with J. S. Bassler, who can boast of catching four and five tons every year. He uses a heavy steel rod bearing a hook at the end. Fitted with rubber boots and warm clothes, Mr. Bassler wades along the stream, jabbing the hook into the muddy bottom. Rudely awakened from his comfortable, ice-cold bed, the turtle is jerked out of the water on the end of the hook.

The turtle hunters usually select some country having numerous small streams. Here they pitch their tent and remain for several days, working within a radius of eight or ten miles from camp. After the streams are exhausted, they move on to another section of country. Sometimes five hundred pounds of turtles are found in the same hole, and thousands of pounds are caught during the usual stay in each camp.

The live turtles are placed in large bags and carried to the road where they are loaded in a wagon. A bag of turtles weighs between one hundred and one hundred and twenty-five pounds. The turtles are later packed in sugar barrels, one on top of another, each barrel weighing as much as three hundred and twenty-five pounds. They will live in this condition for many days. The chief markets, like New York and Chicago, pay from six to twelve cents a pound for turtles, including the shells.

Turtle soup is made from ordinary snapping turtles and not from green sea turtles, as gourmets fondly believe.

Why Logwood Is Worth $200 a Ton

THE great bulk of the logwood from all regions of its growth is used to obtain black dyes which result from its use with alum and iron bases. The use of logwood dates back over two hundred and fifty years, and from that time on the logs from Yucatan and Honduras have been considered far superior to those obtained from Jamaica and Santo Domingo. It may be of interest to note that the logwood tree is not a native of Jamaica.

The first shipment of logs that came into England in about 1550 was obtained at points on the Spanish Main and it seems that at first the dyers were unable to obtain durable colors. In order to protect the public the use of logwood was forbidden in 1581 by an Act of Parliament. The dyers in France and Germany, however, soon developed the use of logwood. After that English dyers were again permitted to use it, with the result that the demand for logwood began to increase. The wood from Campeche soon brought a price as high as $500 per ton, and that from Jamaica about $250. At the present time the Campeche wood sells for about $200 per ton and that from Jamaica and Haiti $100.

The world's present annual consumption of logwood is estimated at about 200,000 tons, of which the United States consumes approximately 30,000 tons. The import statistics for 1914 show that 20,000 tons of logwood came from Jamaica and about 10,000 tons largely from Haiti. The Bureau of Statistics of the Department of Commerce and Labor supplies the following figures in reference to the sources, quantities and values of logwood imported during 1910.

SOURCE	QUANTITY	VALUE
British Honduras	1,005 tons	$ 16,491
British West Indies	11,187 "	137,906
Haiti	19,022 "	200,544
Mexico	449 "	5,381
St. Domingo	434 "	3,914
Other Countries	221 "	4,212

The present bad condition of the dye trade in the United States has called forth numerous propositions for remedying the difficulties, but nothing practical has been done.

The Making of a Telegraph Boy

Training Messengers to Become Managers

A tailoring department is maintained, for the boys must look neat enough to enter the finest hotels in the city. Each boy is measured and provided with two suits for which he pays a small weekly rental. Three tailors keep the uniforms clean and in repair

IT is a big undertaking to produce useful and capable men from boys whose opportunities for education have been limited and who are practically without training. Yet that is the task assumed by one of our great telegraph companies. Its messenger boys are to become not merely bearers of dispatches, but men of character.

Fred Geigle, manager of these boys—and there are several hundred of them—is the man who has charge of the work. He employs and discharges, reprimands or punishes, as the occasion arises. But above all he sets out to win a boy's confidence. Mr. Geigle himself commenced as a messenger boy and worked his way up step by step to the manager's chair. Surely he knows just the conditions under which the boys work. On the other hand, the boys feel instinctively that he is their friend. To him they go confidently for assistance in any difficulty.

From the time the boy hands in his application every precaution is taken conscientiously by the company to safeguard him.

Neatness and courtesy are valuable business assets. The rules presented to a new boy stipulate that his uniform must at all times be in perfect condition, must be clean, in repair, buttons all on, and coat kept buttoned. The company provides as many changes of uniforms as are needed to keep the boys up to

Between calls there is an opportunity to become expert with the typewriter and to learn how to use telegraph instruments. Every boy with any ability has an opportunity to work up to a responsible office position

the standard in appearance, for which service each boy pays a small weekly rental. Three tailors are employed constantly to keep the uniforms clean and in repair. In the summer, washable blouses are provided instead of coats. The company maintains free baths for the boys, with free towels and soap.

Each boy is instructed in simple matters of courtesy. He is taught when and where to remove his cap. He is made to feel that he is identified with an important commercial house, and that his deportment should be such as to be worthy of his company. He knows that if he does not conduct himself properly he will be reported to the manager. His oversights are entered upon the index card, and adverse entries count against him when the time comes for promotion. In this practical manner the boy is taught that good manners bring their reward in dollars and cents.

Great quantities of clothes for messenger boys are kept in the stock room. Each new applicant is fitted with a suit of correct size. The necessary alterations are made in the company's tailoring department

The company also maintains a small circulating library for the use of the boys, a former messenger acting as librarian. Every boy in the messenger service is entitled to the free use of this library.

The company desires to assist every boy to fit himself for something better, if the boy cares to do so; and to further this object, a typewriter is placed in the messengers' waiting-room. Any boy is at liberty to practice upon it while waiting for calls. A set of telegraph instruments has also been installed, with an inside connection, so that any ambitious boy may learn telegraphy and carry on communication with another boy at the end of the line in the same room.

Especially commendable work which Mr. Geigle performs is in training his boys to be men. A messenger boy is subjected to many experiences which rarely come to the boy employed in a business house. The boy's honesty and integrity are tested hourly by the very nature of his service, and he himself is subjected to the wily approaches of those who would profit by his commissions. Thus the boy is compelled to be doubly fortified, first entrenched within his own consciousness lest he be tempted to do wrong; and secondly, he must be ever watchful for the temptation from without which would ensnare him and despoil his employers.

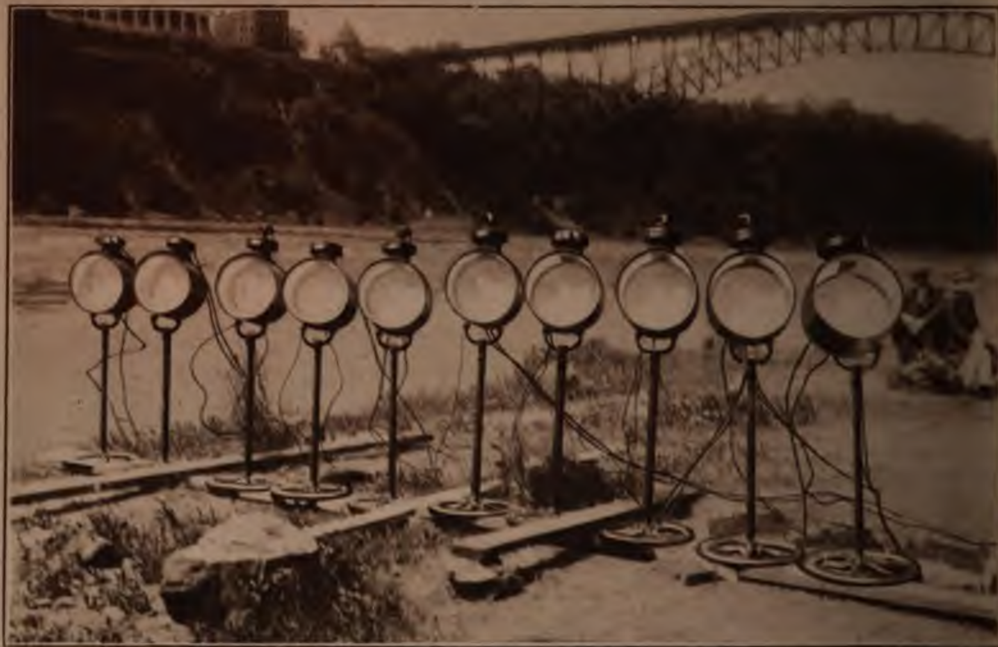
Among several hundred boys, it sometimes happens that one is not so careful or particular in some matters as he should be. This lapse is reported to the manager, and the boy comes before him for explanation. A boy is never discharged for a first offense, unless it be of a very serious nature. Instead, the manager talks it all over with him in the desire to be helpful rather than harsh. The boy is given an opportunity to try again in another location, from which reports are also made. Should the boy fail even a second time to progress satisfactorily he is given still another trial, with the earnest, patient counsel of the manager to show him the right course to pursue.

Making Weather Forecasts with Flowers

WEATHER conditions may be predetermined by means of a unique arrangement, easily prepared by anyone. Procure a bouquet of paper flowers. They may be made or purchased, but their colors must be pink and blue. Dip the flowers in a saturated solution of chloride of cobalt and allow to dry. Repeat the process five or six times; and place the flowers in a suitable vase.

When wet weather is approaching, the flowers retain their original colors, but when it is going to be dry, the pink flowers become purple and the blue ones turn green.

Flood-Lighting Niagara Falls



A battery of incandescent lamps which play upon Niagara's waters. With these lamps Niagara is to be brought out of the night and bathed in electric radiance

ILLUMINATING Niagara Falls at night by artificial sunlight is the ambitious scheme now occupying the attention of prominent engineers and the officials of Niagara Falls, New York, who have authorized an expenditure of ten thousand dollars for the project.

For several nights a battery of twenty-five flood-lights was turned on the American Falls and the rapids of the Niagara River, to the great delight of thousands. Indeed, the effect was so successful as to exceed the expectations of the promoters. It is now planned to double the number of lamps in service and from time to time to enlarge the battery as new lighting effects are desired.

In illuminating the waterfall at night the light is projected from an ingenious patented reflector, which spreads beams of pure, yellow light which very closely resembles sunlight upon the curtain of falling water and mist. An artistic realistic effect is produced, which would be unattainable by any other means. *With this system of* flood-lighting, receiving its power from the Falls themselves, there is no dark center or wing-shadow in the light beam. The Falls are smoothly and softly lighted. On the other hand, the beam is powerful enough to penetrate the densest parts of the rolling mist.

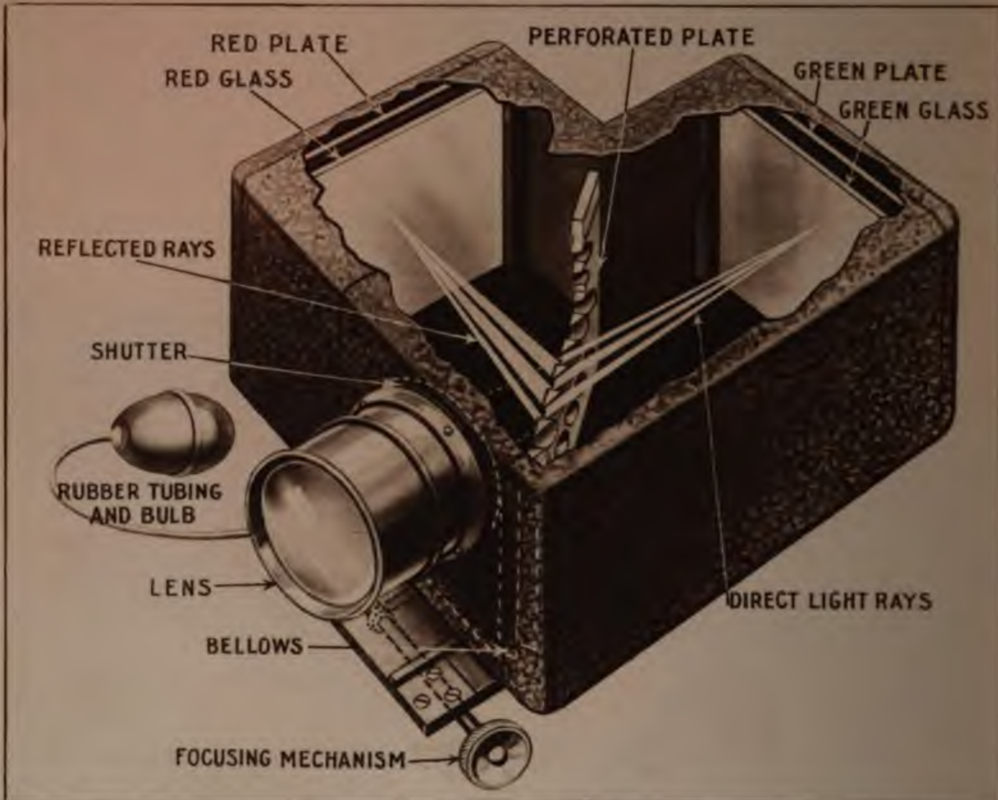
Strange as it may seem, the Falls are thus illuminated not by electric arcs, but by incandescent lamps. This achievement was made possible by the gas-filled lamp, remarkable for its renewing properties. It is a one thousand-watt one hundred and ten-volt tungsten lamp, which is filled with an inert gas, such as nitrogen or argon. Such lamps are now competing successfully with arcs in street-lighting. The reflectors used at the Falls are as true parabolas as it is possible to make them commercially, and they give a powerfully concentrated beam of light rated at one hundred and fifty thousand candlepower in the center of the beam, when used as a flood-lamp, and as high as five hundred thousand candlepower when they are employed as a searchlight.

Artificial Sunlight to See Niagara by Night

Niagara as a night attraction. When the installation is completed the Falls will be illuminated by artificial sunlight from one hundred and thirty incandescent lamps arranged with such skill that their soft rays will not reveal their hiding-place

Photography in Natural Colors

By Lloyd Darling



The Brewster camera, showing the red plate, the green plate, and the perforated partition

COLOR photography is not new. It has been the goal of ambitious inventors ever since scientists really understood something of the nature of light. Nearly all methods of making colored photographs are long and expensive. Though beautiful results were in some cases secured, only an able scientist could manipulate the apparatus, time the exposures, and keep track of the dozens of little things all-essential to securing satisfactory results. Even the Lumière process, widely employed as it is, is handicapped by the fact that the pictures must be viewed through glass.

Most of the previous processes were of the "three-color" type. That is, they depended on the fact that from three colors of the spectrum, red, yellow-green, and blue-violet, all other hues could be made by combination. Negatives of an object were made through red, yellow, and blue filters, and positives therefrom were colored and joined in various ways to make a resultant colored picture.

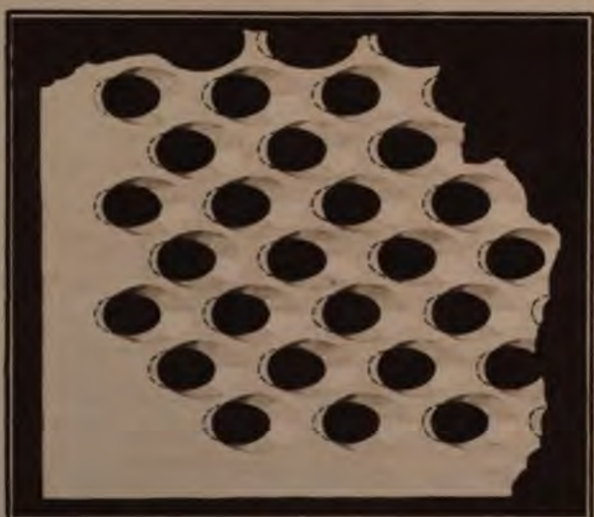
Within recent years encouraging experiments have been made which involve the use of two colors only, red and green. The most recent system of color photography dependant on this method is that of Mr. Percy D. Brewster of New York.

Two Plates Are Used with the Camera

The camera employed in the Brewster system and other two-color systems differs from the ordinary photographer's mainly in that it has two plates instead of the customary one. The one

directly back of the lens is known as the "green" plate; while the other at right angles is referred to as "red." This arises from the fact that light rays reaching the "green" plate must first pass through a green filter, while those falling on the "red" plate are correspondingly filtered by a red glass. The "green" plate is intended to record at the green portion of the spectrum, while the "red" is sensitive to those at the opposite end.

The manner in which the image is conveyed to both plates is interesting. Thus, Mr. Brewster mounts, a few inches back of the camera shutter, a mirror called the "Swiss Cheese" plate, its surface being at a 45° angle with the plane of the lens. The mirror is thus strangely named because it is full of holes, which serve to permit parts of the image to pass through to the "green" plate; the remainder being reflected by the solid part to the "red" plate. Inasmuch as images filtering through the holes overlap after passing the mirror, a complete picture is thrown on the "green" plate—and not a spotted one, as might be expected because of the holes. Likewise the solid portion throws a complete image on the "red" plate. Dividing the light between the two plates in this manner of course lengthens somewhat the time of exposure necessary; otherwise no other effects are ordinarily noticeable.



The "Swiss cheese" mirror. The dotted lines indicate the size of the holes on the reverse side

The same effect can be obtained in many other ways. Thus, in what is known as the "kodachrome" process a plate is employed which, instead of being perforated with Swiss cheese holes, is thinly platinized, so that it can both reflect and transmit light.

It is understood of course that negatives obtained with the Brewster, "Kodachrome," and similar instruments are of the ordinary black-and-white variety—not colored in any way. The "green" plate differs from the ordinary negative only in the fact that it is especially dense where colors at the green end of the spectrum predominated, while the "red" plate likewise records densely roseate hues. From these two negatives positives are made on other plates by ordinary processes of contact printing. The image on the positive from the "green" plate is dyed red and that from the "red" plate green. The two positives are then placed face to face, and the image on one registered with the image on the other.

Hold the combined plates up to the light, and you can see the photographed object in its natural colors. It stands out from the background as striking as the original. The effect is startling, indeed.

Why Two Colors Must Be Employed

The reason for coloring the "green" positive red, and the "red" positive green, as mentioned in the foregoing, is rather elusive and at the same time particularly interesting. Consider for instance the case of a red rose on a background of green leaves. The "green" negative upon development will be almost black where the green leaves appear on the plate, while the rose will be almost transparent. Similarly with the "red" negative, the rose will appear dense, while the green is recorded as a transparent area.

Positives from these two plates will in each case of course be just the oppo-

of the negatives. That is, a positive from the green plate will show the leaves transparent, and the rose dense; while that from the "red" plate will show the leaves dense, and the rose transparent. Dyes used in this process affect only the dense places. It is obvious that if you want a red rose to be red in the resultant picture, you will have to color the positive from the "green" negative red, that being the only one showing the red rose as a dense area. Similarly, you will have to color the positive from the green negative "red," since in this case the leaves are dense. After dyeing them in this manner, the plates pass through a special process to eliminate the opaque black silver on the plates, leaving only the colored images. This process completed, the two plates are placed face to face and registered properly. Then you see the red rose in its proper place among the green leaves.

The next step is to cement these two positive emulsions together. This done, they are stripped from the glass and transferred to paper, canvas, ivory (in the case of a miniature), or any other backing. In their new positions they look not unlike an oil painting, especially when canvas is used as a mount.

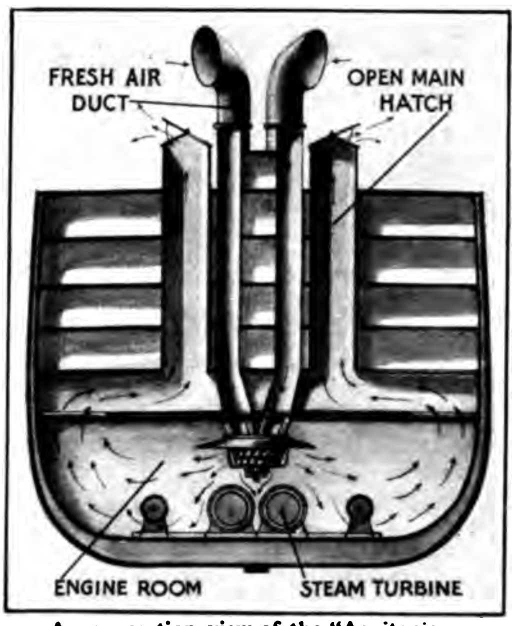
For the sake of simplicity, the foregoing description of the red rose and green background referred only to these two colors. It is understood of course that almost any color which may have been present in the original object also appears in the finished picture. This is possible because red and green combined in different proportions by the process here used will give such desired colors.

How a Steamer's Engine-Room Is Ventilated

PHYSIOLOGISTS have shown in recent years that the chief effect of ventilation and open air treatment depends on the movement, temperature and moisture of the air, and less upon its chemical properties than was expected. For this reason the cooling of overheated engine-rooms, underground or underdeck, is best obtained, as engineers have discovered, by flooding them with fresh air from outside under slight pressure. This positive ventilation or a continuous change of air also removes all noxious gases and smells emanating from the oil and bilges.

The accompanying drawing shows a transverse sectional view of the engine-room of the "Aquitania," with the recommended method for flooding the confined space with cool, fresh air under moderate pressure. The air is delivered into the engine-room by a large open fan placed at the junction of the lower ends of the air-shafts, so that the full volume of fresh air, equal in this instance to about one hundred and fifty thousand cubic feet per minute, is propelled into and properly distributed through the engine-room without loss from delivery ducts.

When desirable, the air in the engine-room may be changed one hundred and twenty times an hour without uncomfortable drafts. The cool air is drawn, not forced, down from the upper deck and delivered laterally by open fans placed low down in the engine-room so as to flood the whole space with air, the cooler incoming air falling towards the floor, displacing the heated air and expelling it up the main hatch. Many transatlantic liners have the ventilating system illustrated.



A cross-section view of the "Aquitania, showing ventilating arrangement

Ten Millions to Save Four Miles

IN the Canadian Rocky Mountains is a giant mass of rock, towering 8,540 feet and known as Mount McDonald. It lies on the route of the Canadian Pacific Railway. Between Mount McDonald on the right and Mount Tupper on the left, the road enters what is known as Rogers Pass. To reach the other side of the Rockies, the trains had to climb two long spiral loops. If they were to tunnel through the mountains the route would be shortened only about four miles, but the grades would be reduced, with the result that much time would be saved as well as wear and tear on rolling stock. Besides, the expense and danger of maintaining and operating four and one-half miles of snowsheds would also be eliminated. Considering these factors, as well as the amazing increase in traffic, an increase which involved double-tracking, it was decided to tunnel Mount McDonald.

Two years were spent by engineers in seeking the most favorable location for a bore. A spot was discovered best suited for an undertaking in civil engineering which compares favorably with the wonderful tunneling that has been done in the Swiss Alps.

The Selkirk Tunnel, as it has been called, is of interest because of the unusual method employed in the boring. In all such work it is important that the excavated material shall be removed with the greatest facility; that the work under way shall not be impeded; and that provision shall be made for carrying high-pressure air pipes for the drills, water pipes and ventilating suction pipes. And so it was decided to dig two tunnels—one of them a "pioneer tunnel," in engineering parlance, the sole function of which is to provide an outlet for the excavated material.

If you will study the pictures appearing on the next page, you will see at once how the pioneer tunnel fulfils its purpose. At the east end the pioneer tunnel was located fifty feet to the north of the center line of the main tunnel and at the west end, fifty feet to the south of it. First of all, an upper center "heading" was dug. In other words, a rather shallow channel was dug along the line of the main tunnel. After this center heading had been made, the work of digging out the main tunnel to its full dimensions proceeded. The material excavated was hauled to the pioneer tunnel, which runs parallel with the main tunnel, through cross-cuts, following the course shown by the arrows in the diagram on the following page.

After being conveyed through the pioneer tunnel, it was carried back again to the main tunnel, but, of course, at a point far removed from the scene of operations. After that, it was hauled out on a trestle over standard-gage tracks through the main tunnel and dumped into regular railway cars. The excavation was, of course, all done by steam shovels of one and a half cubic capacity, which means that at a single scoop, a shovel would dig out about an ordinary wagonload of dirt and rock. The dirt cars were hauled to the mouth of the tunnel by standard-gage compressed-air locomotives.

The tunnel, which is five miles long, lowers the summit of the line by five hundred and fifty-two feet. Its estimated cost is over ten million dollars.

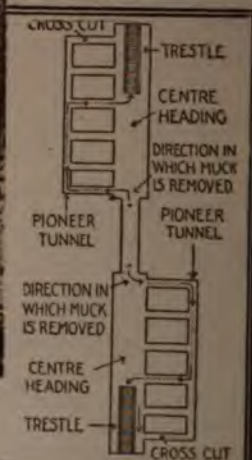
The tunnel is twenty-nine feet wide and twenty-three feet high and follows a straight line under Mount McDonald, emerging in the Beaver Valley beyond at a point about one thousand feet below the present railroad route.

The eastern end is directly below Hermit, a station just east of Rogers Pass. The highest point reached in the tunnel is three thousand seven hundred and ninety-five feet below the summit of Mount McDonald peak. Up to the interior summit the passage through the tunnel has a grade of one per cent. The climb for the tunnel is made by the railroad on the most northerly station on its route. The tunnel route originally discovered by the engineers was six miles long, but this was gradually decreased to conform to the five-mile tunnel. The pass gets its name from Major A. B. Rogers, who penetrated the fastnesses of the Selkirks in 1861 and discovered this opening through the range.

Tunneling Through the Canadian Rockies

One of the intersections of the pioneer tunnel with the main tunnel. Horses were used to haul the muck cars to the point where they were dumped into railroad cars. From this point to the mouth of the tunnel standard-gage compressed-air locomotives were employed

A view of the entrance to the tunnel under Mount McDonald. It emerges at a point in the Bear Valley about one thousand feet below the present railroad route



In the lower picture the mountain is shown sliced away to reveal the pioneer and main tunnels, as well as the laterals connecting the two. The material excavated was hauled through the pioneer tunnel and then through the main tunnel as indicated by the arrows in the diagram on the right

Embalming a duet by Lina Cavalieri and Lucien Muratore. Cavalieri was formerly a member of the Metropolitan Opera Company. Muratore is a distinguished Italian tenor. The photograph shows in a general way how songs with orchestral accompaniment are recorded. Sometimes the phonograph projects through a partition, so that the singer sees only its mouth. Often five or six phonographs are used simultaneously to make records. In making master records, the artists always sing twice

Singing for the Phonograph

THE recording of the human voice on the phonograph is almost a science in itself—not so much as the artist is concerned as the laboratory head who is responsible for the clearness of the ultimate record. While each phonograph company has its own system of arranging the recording phonograph relatively to the orchestra and artist, the essential principles are very much the same in all laboratories.

As a general rule the musicians are perched midway between floor and ceiling, with their instruments pointing toward the horn of the recording phonograph. Men who play the tuba and similar brass instruments turn their backs to the phonograph so that the mouths of the instruments may project their growls and blasts toward the horn. In order that the tuba players may see the conductor of the orchestra, mirrors are placed in front of them, which reflect the movements of his baton.

For violin solos, an ordinary violin is used, the artist usually playing directly in front of a horn projecting through a partition. This is true of chamber music and all records in which the violin tone can be heard with sufficient distinctness. In heavy orchestral pieces, however, a special instrument called, after its inventor, the Stroh violin, is used. It seems that the sounds of the ordinary violin are difficult to produce, especially at a distance. Stroh devised a violin which has no sounding-board. It comprises simply a bridge, over which the strings are stretched in the usual manner, and a horn which amplifies the sounds. This instrument is now used in all phonograph laboratories. On the finished phonograph record its sounds are hardly to be distinguished from those of an ordinary violin.

Many experiments have been made to determine the best shape of room in which to make records. Edison, for example, tested almost every conceivable form. He even went so far as to build a room in the shape of a horn, the small end of which terminated in the [illegible]-

graph itself. The singer stood practically upon the edge of this huge horn's mouth, for such was the room. The results were no better than those obtained by stationing the singer in front of an ordinary phonograph in an ordinary room. As a result we find that no special effort is made by the phonograph companies to utilize rooms of special shape so as to gather all sounds and concentrate them upon the record.

A London cabby designed this three-wheeled cab. The third wheel prevents the cab from tipping over, even when making the shortest and quickest of turns

It is difficult to believe that the technique of making records cannot be improved. In view of the elaborate studies of echoes and reverberations made in large auditoriums for the purpose of improving their acoustic properties, it seems that the time is now ripe for a new series of experiments which will show how those sounds may be gathered which are now lost.

The record made by the artist is called a master record. In fact, two records are made, one being hermetically sealed and stored away in the company's archives for future generations. The other record is used for the preparation of a die for making commercial records.

This Cab Simply Can't Tip Over

A CITY cabman of London has devised and built an attachment in the form of a third wheel for his cab, which, he claims, adequately prevents the cab from upsetting, even in going around the sharpest and swiftest of curves. The additional wheel is placed under the driver's seat, almost in dangerous proximity to the horse's heels. It is fitted with springs on either side and performs the incidental function of absorbing jars and jolts. Even in spite of the added factor of safety which the third wheel provides, it is doubtful if the cab will continue to be popular in London. Cheap taxicab service and the famous London 'bus have crowded the horse almost entirely from London thoroughfares. Hansoms, which are just now beginning to lose their vogue in New York, have not been seen in London streets for several years. One of the last to be removed has been

placed in the British Museum as a relic for future generations to gape at.

Gasoline in Bulk for Panama

GASOLINE is being shipped in bulk to Panama. The first consignment arrived at Balboa in February and was unloaded into the new storage tank recently erected by the Panama Canal Commission. In Panama there is now stored fuel for ships of all sorts, gasoline, crude oil and Diesel oil. Considerable gasoline is still on hand in Panama in drums, the supply being sufficient to last at the present rate of consumption about five months.

Trench-Digging by Machinery

MODERN engineering requirements coupled with a persistent demand for labor-saving devices have brought into being several types

Above, the endless chain type of machine excavating a twelve-foot trench with cutting buckets. To the right, the wheel type of machine with its driving mechanism at the top

of trench-digging apparatus which are of ingenious construction. Of all manual labor, digging trenches by hand or excavating on a large scale by hand is the most laborious and expensive method. One of the largest single items in a contractor's specification, until the modern digging machines came along, concerned the amount of excavating to be done. With the several new types of mechanical excavators this item can be reduced materially.

In the machines recently marketed two general principles seem to be used. In one, cutting buckets are attached to an endless chain, while in the other they are mounted on the periphery of a wheel. In both methods the buckets are forced to bite into the ground at the end of a trench, carrying the dirt up with them as they rise.

The endless chain type of machine grips the dirt and hoists it to the surface in the same way as chain buckets on an elevator-hoist lift grain to upper bins. The wheel type has a curious mechanical feature in that the wheel itself has no central hub. Instead, it consists merely of a rim supported by four sets of rollers mounted on an internal framework. The reason for this is that it gets all the driving machinery up near the top of the wheel, enabling a deeper trench to be dug with a smaller wheel than would otherwise be possible. In fact both types have their driving mechanism located at the upper end of the chain, and both also make use of a transverse conveyor belt to carry the excavated material to wagons as fast as it is brought up.

Behind the wheel on the wheel type of machine is located a bracket-like or L-shaped framework, known as the "shoe."

This slides along the bottom of the trench and supports the rear end of the wheel frame work. Depth of digging is controlled by raising or lowering the front end of this framework, the rear portion of course riding along on the "shoe" according to the depth of the front end. A special feature of this "shoe" is that a man can ride on it laying tile or pipe as fast as the digging progresses.

Many widths and depths of trenches can be cut by the machines. Some have been made six feet wide and fifteen feet deep. One machine dug two hundred rods of eleven and one-half inch trench thirty inches deep in a ten-hour day, and another dug a thousand feet of twenty-inch trench five and one-half feet deep in the same time. Small boulders, tree roots, and similar barriers offer no great obstruction, and the machines accomplish work under difficult circumstances with a celerity that is surprising.

"Caterpillar" wheels enable the big machine to travel over soft ground

Various modifications of the chain-type and wheel-type have been made to fit special conditions. These relate largely to the shape of buckets used, since digging an open trench in sandy soil requires a far different kind of bucket than making a clean-cut channel in hard clay. To enable the machines to travel over wet, soft ground "caterpillar" wheels are used.

In a ten-hour day this machine will do the work of two hundred men

Traveling by Parcel Post

THOUGH our parcel post is a wonderful system, enabling us to send all kinds of strange things by mail, the English system can do one thing which we have, as yet, not attemped.

An Englishman who was in a hurry to reach a part of London with which he was unfamiliar, called at the general post office to consult a directory. Upon explaining his case, the clerk gave him the startling information that he could go by parcel post for the payment of threepence a mile.

He was accordingly placed in charge of a messenger who took him to his destination. The boy carried a printed slip on which was written "Article required to be delived" with a description of the parcel following.

Detecting Fires in the Holds of Transatlantic Liners

BY means of an apparatus which is now found on many of the large trans-Atlantic steamships, the officer on duty on the bridge can instantly detect any fire which breaks out in any of the holds or compartments.

This efficient indicator consists of a set of pipes extending from each of the holds directly to the wheelhouse. At the terminals in the wheelhouse is a set of electric fans which draw air from the holds into a glass case to which the pipes lead. Should a fire start in a hold, some of the smoke would be drawn through the tubes into the glass case, and would be noticed by the officer.

As soon as the fire is discovered, the officer opens the case and fastens to the open end of the tube a steam pipe, which sends live steam through the tube into the compartment and smothers the blaze.

This device has met with considerable objection among ships' officers, because it was claimed that the noise of the electric fans was found very disturbing to the officer on duty, and also that the apparatus took up a large amount of space, particularly on large steamers with numerous compartments to be protected.

In order to overcome these objections, the inventor, William Rich, an American, living in Liverpool, England, has taken out patents for improvements over his original device. A set of small glass cases, one serving for several compartments, is located on the bridge, or wheelhouse, while the remainder of the apparatus is located in a more convenient part of the ship. In the terminal compartment for the tubes is a set of fans which draw the air from the holds, and another fan which serves to send a smaller amount of air from each of these tubes through pipes into the device in the wheelhouse. Each of these smaller tubes leads into a bottle or container which is filled with lime water.

If a fire should break out in a hold, the smoke is drawn into the terminal box for the tubes as before, but is immediately drawn on until it reaches the glass jars containing lime water on the bridge or in the wheelhouse. The carbon dioxide carried up with the smoke turns the fluid to a milky color. The officer can then order live steam turned into the tubes to smother the fire.

The moment a fire breaks out in the hold, it is detected by the officer in the pilot house and by the watchman on deck, by means of the system of tubes and fans indicated, which carry the smoke to the bridge or the deck

With this new device, all the fans and the cumbersome apparatus are located in a distant part of the ship, while only the small set of glass cases is found in the wheelhouse, where saving of space is of more importance.

The chief advatages in the system obviously lie in the fact that a fire can be discovered immediately, and can be extinguished quickly by means of the same apparatus.

Catching Mailed Eggs from Swiftly-Moving Trains

EGGS may now be delivered from a station platform and caught with ease and safety by the mail car of a fast-speeding express train, by means of an automatic mail exchange system recently adopted by a large western railroad.

This device works with great speed. When the train nears a station a lever on the truck of the mail car is operated by a track trip, thus setting in motion the system of cams which perform the functions of discharging and receiving the mail from the station.

A set of arms move out from the side of the car, and as the train passes, the suspended pouches of mail are caught by the arms and drawn into the car. Another cam, deriving its power from the car axle, picks up the mail pouches which are to be delivered at the station, and deposits them in a chute, where they slide into a trough on the station platform. This chute extends down until it nearly touches the platform, and the pouches fall but a few inches. They slide on the smooth surface of the trough until their fall is broken. As soon as the train has passed the station, the apparatus is automatically drawn inside the car and the doors are locked.

The much advertised delivery of eggs by parcel post has produced many patented devices for handling mail sacks without breakage. This one is already carrying eggs

Inspecting the Inside of the Earth

IN mining for coal or metals, operators must know a number of things about their claims in advance unless they are out-and-out gamblers. Before starting operations at a mine the thickness, extent and richness of the vein must be estimated in order to determine whether the mine can be worked profitably. The depth of the vein from the surface, the dip or angle at which it lies and the nature of the materials that will be encountered before reaching paying values, are also factors of the greatest importance. In a word, the mine operator must have a good idea of the "lay of the land" in advance, or he may be doomed to failure from the start.

All of these questions are easily answered in advance by means of core drills. Think of the way a corer takes out the heart of an apple and you have the main idea of the core drill. These drills have been used for taking samples out of the earth at varying depths from a few yards to several thousand feet. The speed of drilling, of course, depends upon the size of the core and the hardness of the rock, but the average is probably between two and four feet per hour. Several typical cores are illustrated.

How the drill samples the earth through which the boring is made

Figure 1 illustrates, in section, a core drill penetrating loose material composed of soft rock and earth. Here the cutting bit is shown with several sharp cutting edges, and the core barrel is about three-quarters filled with the different kinds of rock that have been penetrated.

Figure 2 shows a core drill employing a steel shot bit, which type is used for cutting hard, solid rock. The rod *F* extending to the surface of the ground imparts a rotary motion to the cutting tool. As the drill sinks deeper and deeper, this rod is extended correspondingly by screwing pieces into it at the top. The rod is hollow and through it are fed water and very hard small steel shot. The shot settles, entering the diagonal slot near the bottom of the bit which feeds it beneath the rotating bit, as shown at *L*. Here the weight of the drill, combined with the abrasive qualities of the shot, rapidly wears away the rock and permits the cutter to settle around the core.

While the core is being made, the cuttings are washed upwards by the stream of water and settle in the receptacle *B*, which is known as a calyx. This gives an additional record, in inverse order, of the rock and earth penetrated, the materials being in pulverized form, suitable for assay purposes. Figure 3 illustrates this point and also shows how the core is broken preparatory to extracting a piece. For this purpose, pebbles are fed into the drill in place of the shot. They jam around the core near the bottom and break it off as the drill is rotated. This wedged material also holds the core in place while the drill is being raised to the surface.

Piles of cores from the drill. Here is a record of the contents of the earth for hundreds of feet below the surface

These drills, while sinking deep into the ground, constantly send up samples of the earth for examination. They are in the form of solid rods, large or small (as here)

With several soundings thus made in different parts of a property and accurate records kept of the material encountered at different depths, it is a simple matter to map the various underlying strata and eliminate absolutely all guesswork from subsequent operations.

The Size of a Railway Station

LOVERS of statistics will be interested to know that in the concourse of the express level of the Grand Central Station, New York, the old City Hall of that city could be placed with twenty-eight feet to spare at either end and with one foot clear on each side. The top of the statue on the City Hall would be nearly fifteen feet under the ceiling. The number of passengers handled annually at this great station increased from fifteen million, seven hundred and fifty thousand in 1903 to twenty million, eight hundred thousand in 1914. In 1905, nine hundred and eighty-two thousand cars entered the station, and in 1914 there were one million, one hundred and twenty-six thousand. Fewer trains, however, are entering the station, for in 1905 there were two hundred and seven thousand eight hundred trains, while in 1914 there were but one hundred and eighty-two thousand five hundred. This decrease is due to the fact that more cars are hauled by the electric locomotives in one train than were hauled by the steam locomotives, and therefore fewer trains are required than heretofore.

Fig. 1 Fig. 2 Fig. 3

Typical cores and how they are procured. Fig. 1 is working through loose material, with a sharp-pointed drill. Fig. 2 is using steel shot to cut through hard rock. Fig. 3 shows the use of water in cutting, also how pebbles are used to break and hold the core preparatory to stopping the work

Spiders That Work for a Living

They Start and Stop Work When the Whistle Blows

A spider is made to give up his thread by whirling him on a frame. He thinks he is spinning a web. The thread is used by optical instrument makers

IN Hoboken, N. J., is a colony of two hundred spiders which start and stop work when the whistle blows. They are probably the most indispensable workmen in one of the largest surveying instrument factories in this country. It is their duty to spin the delicate thread which is used for the cross-hairs to mark the exact center of the object lens in the surveyor's telescope.

The spiders produce only during August and September. In that time they spin thousands of yards of web which is wound upon metal frames, and stored away until needed. A few weeks ago the entire colony, for no apparent reason, went on a strike. Everybody was worried until the "forewoman" of the spiders, after patient coaxing, finally induced them to begin spinning again.

Spider web is the only suitable material yet discovered for the cross hairs of surveying instruments. Almost invisible as this fibre is to the naked eye, it is brought up in the powerful lenses of the telescope to the size of a man's thumb, so that all defects, if there happened to be any, would be magnified to such a degree that the web should be useless. Human hair has been tried, but when magnified it has the apparent dimensions of a rough-hewn lamp post. Moreover, human hair is transparent, and cross hairs must be opaque.

A spider "at work" dangles in the air by its invisible thread, the upper end being attached to a metal wire frame whirled in the hands of a girl. The girl first places the spider on her hand until the protruding end of the thread has become attached. When the spider attempts to leap to the ground, this end is quickly attached to the center of the whirling frame, and as the spider pays out thread from its pouch, this line is wrapped around the frame. Several hundred feet of thread can be removed from a spider at one time.

The spiders are kept in a large room, under the supervision of three girls and a forewoman. When not spinning, the little workmen are placed in a large wooden cage. Flies are the chief article of diet. During the fall and winter months, the spider colony usually dies, so that an entirely new corps of workmen must be recruited. Not every spider will do—only large, fat fellows that spin a tough round thread are suitable. Boys search barns, meadows and marshes for the spiders' lairs. By early summer, the spider cage is generally filled.

Serving Food on the Run

THE war has done many unexpected things in this country. It has touched the every-day facts of life in a degree unimagined prior to August 1, 1914. It has even affected the manner in which food is served. Since the war began, the Remington Arms and Ammunition Company has erected a plant at Bridgeport, Conn., which is more than a third of a mile long. This plant, with a capacity for eighteen thousand men, is working throughout the twenty-four hours in eight-hour shifts. As soon as a man leaves his machine, another takes his place. Men working for only eight hours a day, do not require, and, if they are working on piece, do not desire, a full hour for meals. A half-hour is long enough for most of them.

But a man cannot devote much time to eating if he must walk a third of a mile in search of food and then return to his place. So a "cafémobile" has been invented to meet his requirements. This, in fact, is a lunch counter on wheels. It is supplied with metal compartments for different kinds of food which should be warm when served, as well as for fruit, sandwiches, pies, etc. At different points throughout the factory provision has been made for attaching it to an electric circuit. By this means the soups, hash, potatoes, coffee, and meat can be heated readily.

Just before the lunch hour the squadron of "cafémobiles" sets out from the restaurant, each loaded with a supply of food. These are pushed by men in white caps, blouses and aprons. Each is trundled to a different place in the factory, previously assigned, and takes up a position near the electric connection. The folding counter is turned back and the oranges, apples, pies, sandwiches and milk set out in tempting array.

In turning out high-priced munitions every minute is precious for the men in the factories. So, a Bridgeport firm uses the "cafémobile"—a lunch-counter on wheels which saves the machinist on piece-work the time required to walk a third of a mile from his lathe to his food. By means of electric connections, foods are served hot

Putting Speed in Telephone Directories

A SERIES of experiments were recently conducted by the New York Telephone Company to ascertain the quickness with which a telephone number could be found with the book printed in three different ways.

Testing the speed of telephone directories. Names in the arrangement adopted were found in 9.28 seconds as against 10.36 seconds in the old arrangement

Dr. J. W. Baird, Director of the psychological laboratory at Clarke University, Worcester, Massachusetts, was called in to supplement the work of the telephone men by conducting other tests, using a variety of type arrangements. Dr. Baird made nearly four thousand experiments to determine the ease and speed with which the average person could find a number on pages of the directory set up in various forms. Thirty-two men and women were selected as subjects for the tests. Care was taken that these individuals should represent radically different occupations and degrees of experience in the use of the directory.

Pages with names beginning with the letters I and M and S were selected when tests showed that they varied sufficiently in difficulty to fulfill the purpose of the experiments.

Twelve pages were subjected to experiments, an I-page, an M-page, and an S-page, being printed in each of four different page arrangements and mounted on cardboard. Each page was placed in a separate "booklet." While the individual tested was looking up a number, the experimenters held stop-watches measuring the time elapsing from the opening of the booklet until the subject found and pronounced the number.

To find a telephone number in the old telephone directory, the pages of which were set in three-column measure, required an average time of 10.36 seconds. When the subscribers' names were printed in a four-column measure without indentation or leading, the finding time increased to 10.69 seconds. When the lines in the four-column page were set in "staggered" arrangement, i. e., in alternate indentation, the finding time was reduced to 10.14 seconds. When the type on the four-column page was made slightly higher and, moreover, narrower, taking eleven lines instead of twelve lines to the inch, the finding time was cut to 9.28 seconds. It was this arrangement of the page that was chosen, cutting 1.08 seconds from the 10.36 seconds required by the average subscriber to find a number in the old telephone book. This is a gain of more than ten per cent.

The Finger Talk of Chicago's Wheat-Pit

THE Chicago Board of Trade is by far the most important grain exchange, not only of this country, but of the world, and few people are familiar with its method of operation.

People who visit the Board of Trade are perhaps most impressed by the sign language used in buying and selling grain for future delivery. Unlike anything else seen in any other line of business this wonderful system, while simple in its execution, nevertheless puzzles the uninitiated. It is a system that has grown up with the Board, and traders would be helpless without it. In that awful din where hundreds of men and boys are rushing about and shouting and countless telegraph instruments are clicking, individual voices are smothered and the trader must talk with his hands.

He has no time to waste—a lost second may mean hundreds of dollars to him. By a simple movement of his fingers the trader makes it known whether he would buy or sell, what price he is willing to pay or take and what *quantity he wishes to trade* in. All the information necessary to consummate a deal, involving perhaps thousands of dollars, is conveyed by a few motions of the hand.

Each finger extended represents one-eighth of a cent. Thus when all four fingers and the thumb are extended, all being spread out from one another, it means five-eighths. When the four fingers and thumb are extended, but are pressed close together, it represents three-quarters. The clenched hand with the thumb alone extended is seven-eighths, while for an even cent the closed fist is used. The thumb protruding between the index and big finger is the signal for a split quotation. Nothing less than 10,000 bushels can be traded in on a split quotation, which if 90⅝—¾, means that half is taken at 90⅝ cents and half at 90¾ cents. These characters refer to the price, and the hands and fingers are held in a horizontal position. When displayed vertically the quantity is indicated, each extended finger representing 5,000 bushels. When the desire is to sell, the palm of the hand is held outward, and when the trader wishes to buy he signals with the palm facing him.

Where voices are smothered in the din, and where seconds may mean fortunes made or lost, traders resort to an effective sign language to buy and sell grain

The Sensitive Brazil Nut

The Nuts Are Stored on Board River Lighters to the Nearest Port of Call for Ocean Steamers. They Are Turned Over with Shovels Each Day and Ventilators Keep a Current of Air Circulating Below Decks

A POD with a diameter of from five to six inches, in a thick, hard woody outer covering, contains the so-called Brazil nut of commerce, from twenty to twenty-four of these seeds being closely packed in one shell. On board the vessels the greatest care is taken of the nuts. They are turned over daily and kept supplied with a constant current of fresh air. Twenty-four hours of stormy weather in which the ventilators have to be closed is sufficient to ruin an entire cargo. Every precaution is taken to keep the atmosphere "comfortable," for the sensitive nut feels the slightest change of temperature.

As they begin to ripen the pods fall and are gathered by the natives, who, cutting the outer shell with a machete, collect the nuts and carry them in baskets to the rivers on which they are transported by canoe, launch, or river steamers, to the nearest port of call for ocean steamers on the Amazon River.

Steel Tubs Are Used in Transferring the Nuts to the Ocean-Going Steamers from the Lighters as an Extra Precaution Against Dampness

Supplying the Market with Ducks From

Above: A duck farm where 124,000 ducks are raised for the market each year. About seven thousand ducks are hatched each week. The photograph shows the ducks drinking from a trough. Water is supplied from the pipe running above

Below: Taking the temperature of the eggs in the incubator. About 2,200 ducks are kept in the nest pens. The eggs are gathered from these pens at the rate of 1,800 a day and put in the incubator

Above: The farm upon which the ducks are raised is traversed by a creek which is divided into pens with sloping banks of sand upon which the feeding troughs are placed. The brooding season is not continuous. The incubators turn out their hatchings from early in March until early in July. Marketing of the six-months-old and year-old birds begins in April and lasts until about November. The season for the younger ducklings is considerably shorter

The Largest Duck Farm in the World

Above: A huge flock of full-grown ducks, ready for the market. The ducks are kept until they are about eleven weeks old, when they are killed, picked, and dressed for city consumers

Below: Food is carried to the numerous pens in cars which run on a narrow elevated railway. Twenty tons of feed are shoveled out in a day. The feed consists of corn, oats and other grain and green food

Trapping English Sparrows for Food

The mouths of the funnel are just large enough to admit the sparrow and keep him prisoner

The bird-trap can be used at any place where sparrows congregate, even on the roofs of city apartment houses

HEREWITH is shown a trap for catching the English sparrow which is one hundred per cent efficient, if properly operated. It is made of tinned wire, electrically welded, strong and durable. The size of the trap is thirty-six by eighteen by twelve inches, and weighs twenty-five pounds.

The United States Department of Agriculture advocates the destruction of the English sparrows, calling them "noisy, quarrelsome, filthy and destructive." Native song-birds will never come back to our gardens in increasing numbers until the English sparrow is banished. These pugnacious birds are extremely cunning, and it is hard to trap them. But there is no trouble in enticing them into the trap shown if the proper kind of bait is used for a particular locality.

The flexible needle-points at the mouths of the funnels can be adjusted so as to be just large enough to admit the sparrow and yet not large enough for him to return. One family who used cracked corn for bait caught seven hundred and twenty-nine sparrows in sixty days. The usual method is to sprinkle bread crumbs for six feet around the trap, leading the crumbs into the funnel. Large pieces of stale bread are used near and in the trap. Sparrows, being like hogs, in that they like to get where the big feed is, soon go from the first into the second division, from which they are easily forced into the last part, from which they are taken.

There is no reason why sparrows should not be utilized for food, as they have been in the Old World for centuries. Their flesh is palatable, and though their bodies are small, their number fully compensates for their lack of size. Birds that have been trapped have been kept in large out-door cages, sheltered from storms and cold winds, until they are wanted for the table. It is unprofitable to keep them long, as the quantity of grain or other food they require daily amounts to more than half their own weight. A variety of food is necessary to keep them in good condition. Bread, oats, wheat, bran and corn-meal mush, lettuce, cabbage and tender shoots of sprouting grain are some of the things they relish. Some time ago ex-Governor Cox of Ohio gave a banquet to some of his friends, when the piece de resistance for the occasion was a sparrow-pie. Until after the banquet the guests were under the impression they were eating a pie made of squabs or reed-birds.

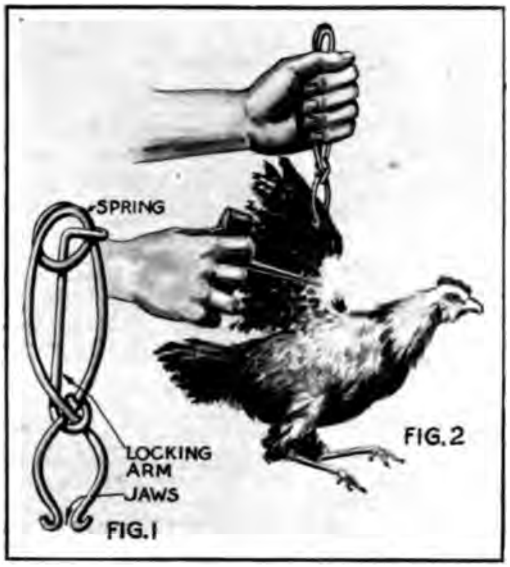
Improving the Imperfect Hen

Ingenious man, after considering the hen, reduces her to a mere egg-laying machine

By George Wörts

IF occasional assaults upon the patent office by ingenious, inventive gentlemen from all parts of this country are to be taken seriously, Mother Nature made some silly mistakes when she devised and constructed the *gallus domesticus*, otherwise known as the barnyard fowl.

When Nature provided the hen with two legs, a head, feathers and a mysterious internal mechanism which disgorges an egg on occasion, she left the poor thing with a woefully incomplete equipment for living the barnyard life. In view of Nature's negligence, brains mightier than the hen's now buzz through the long days, conceiving apparatus, mechanisms and "devices"—mostly "devices"—for making the imperfect *gallus domesticus* live a blamelessly chaste and worthwhile existence.



A hen handle. With it, the fowl may be effectually powdered. The wing-clip clamps the members securely while the germicide is being applied liberally

If the learned opinions of poultry improvers could be combined into a barnyard creed which the hen could study at her leisure, and if it were printed legibly and tacked up conspicuously within and without the hen roost, then the hen might raise herself in the estimation of those who consider her imperfect. Why not, indeed? The suggestion is offered freely to the entire poultry universe. Why not

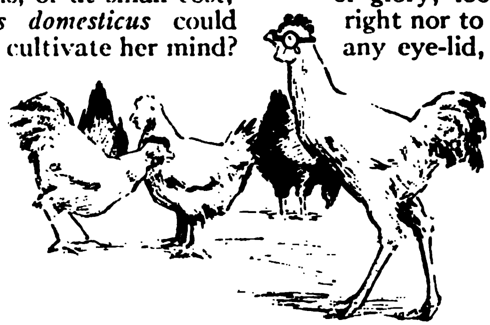
An inspection of the rooster's beak will reveal the reason for his apparent penitence. Inventive man has muzzled the rooster. The reason being that he (the rooster) occasionally plucked beakfuls of feathers from the wings of his wives

The ghost-like figure of a hen seen soaring over the hen-house mirrors the thoughts and desires of the hen in the foreground. Her wing is clamped to her side by means of a capable wire clip. She cannot fly; she can only dream of flying

The hen at the left has not been harnessed with the end in view of giving the children a ride. She has submitted to the indignity of a "setting preventer." When she attempts to climb into a nest and settle down, the imagination of the reader can supply her subsequent astonishment and chagrin. Will the rooster at the right scratch up the new garden? Not after he tries it with this leg attachment designed to prevent just that performance

have a creed, or a set of poultry commandments struck off from the press and distributed gratis, or at small cost, so that the *gallus domesticus* could memorize them, and cultivate her mind?

Differences of opinion might arise regarding the necessary content of this creed; but after thoughtful examination of the available material secured from the Patent Office, the following resolutions which encompass all the important points have been drawn up:



This rooster is not attending a poultry school, despite the evidence to the contrary, which the goggles create. A thoughtful inventor has simply provided him with a protection for his eyes. It can be seen that the rooster appreciates this courtesy highly. Strangely, the lady hen to the left seems on the point of fainting at sight of her husband's odd appearance

"I will not set when my master denies me that pleasure; neither will I fly maliciously out of the confines which my master has provided for me; I will render a correctly audited account of the number of eggs laid by my humble self in the week; and all of these eggs shall bear my personal trademark; I will lie in a posture according to the will of my merciful master, awaiting sacrifice, moving neither head nor tail feather; never will I scratch up the gardens which the Lord seemingly provideth not for me; ever will I tread in the paths wired off for me, bringing forth the young of my species whenever it is demanded of me, and sitting uncomplainingly upon glass eggs, door-knobs and other objects which my master kindly provides for me. Yea, verily, I will walk in the cow-paths of glory, looking neither to my right nor to my left, nor winking any eye-lid, thus that my sacred name shall be saved from the unutterable disgrace into which it has been dragged by my unfeathered sisters in the great, ungodly cities."

One of the heartiest laughs we have ever wrung from a joke-book was recently unearthed from what is occasionally the greatest of all joke-books—the Patent Office Gazette. The joke in point had to do with an enterprising apparatus devised to prevent the hen ambitious to set from realizing her ambitions. It comprised a dozen eggs all of which were connected together by means of short lengths

When the chicken is caught its legs are clamped, making it helpless and passive

of rubber tubing through which ice-cold water from a tank suspended from the top of the henhouse was run to the eggs. When the mothering instinct became too great for a hen to resist she would mount these joke-eggs. When her warm breast came in contact with the frigid eggs, she would leap off with a cackle of anguish, and thereafter be cured of the setting habit.

Was it not ingenious? Indeed it was.

A contraption devised for the same purpose and also unearthed from the scintillating pages of the Patent Office Gazette is displayed pictorially in these pages. It has a devilish ingenuity all unto itself. Look at this picture in which a hen may be observed leaping angrily from a nest of spikes. This pointed warning to the hen who aches to set, belongs to the same category as the machines brought out for purposes of inflicting slow torture at the time of the Spanish Inquisition. Some prehistoric fragment of barbarism in all of us makes a device of this sort unusually interesting. Unquestionably, if this invention were installed in a barnyard, the farmer-owner could charge ten cents admission, and the public would get a generous ten cents' worth in watching fowl agony. Can you put your own soul through the misery to which the would-be-mother hen, with the delicacy which that feeling is supposed to bring, submits herself when she settles calmly down, with every honorable intention, upon a nest of naked, brutal spikes?

When the would-be-mother hen approaches this nest she is received by an array of sprouting spikes. The man who conceived the idea probably derived it from a volume upon the Spanish Inquisition. It is indeed most effective. The hen squats upon the spurs; and she arises with cackles of wrath, cured of her desire to set

The hen-house-of-horrors, if properly furnished with these machines of malice, would not satisfy itself merely with ice-cold eggs and spiked nests. Other inventions, if they were attached, would transform the peaceful hen into a picturesque spectacle, a cross between a taxicab and an infernal machine. In fact, if the hen were properly equipped with all the "useful devices" which man has thoughtfully and modestly provided, she would not only be bound, gagged, fettered, spiked and frozen; but her vision would be guided by goggles; she would stamp each egg as it was laid with a trade-mark. Altogether she would bear so much mechanical miscellany upon her innocent young shoulders that she could neither sit in the forbidden nest, run amuck in the forbidden garden, fly into the forbidden air, nor, indeed, could she lay the luscious egg, nor hatch the necessary and succulent young springling.

Human sympathy with the helpless unfortunates would prompt one to say, "Let the poor creatures alone!" Nevertheless, the farmer may see in the numerous inventions mentioned helpful means of augmenting and protecting his egg supply, and if so, humanitarians have no right to hinder him from employing them.

Chasing Butterflies for Money

By J. McDunnough

MORE or less periodically a lurid account crops out in the newspapers to the effect that some millionaire, usually a member of the Rothschild family, has paid a fabulous sum for a butterfly—a sum ranging anywhere, according to the vividness of the reporter's imagination, from five hundred dollars to ten thousand dollars. The effect on the average reader is either to cause a sneer of pity that anyone, even a millionaire, can be such a fool as to part with so much money for so frail and useless an object or else to create the impression that it is simply necessary to go out on the front porch or into the back yard with a hat or broom or makeshift net, knock down some unwary member of the butterfly family which happens to stray within reach, impale it on a pin in a cardboard box and ship it post haste to the aforesaid millionaire in order to receive by return mail a substantial check.

These newspaper tales seem to have a common origin in the fact that some twenty or thirty years ago an expedition to one of the islands of the Malay Archipelago was financed by a member of the Rothschild family. One of the prime objects of this expedition was to secure specimens of a large butterfly of a pure black color of which only a single specimen was known at the time. In this the collectors were perfectly successful. Besides securing specimens of the species in question, however, the expedition brought back a vast quantity of other material of great scientific value. The total expenses were doubtless considerable, probably well above ten thousand dollars; but it was not correct to assert, as it was asserted at the time, that this sum had been expended for a single butterfly. It was not spent even for specimens of a single species of butterfly.

The variety of butterflies is not as a rule due to the fact that there is actually a great scarcity of certain species in Nature, but rather because these species frequent inaccessible regions or countries. Those brilliant metallic blue butterflies of South America, the giant Morphos, generally fly in the tree tops of almost impenetrable jungles, making their capture on the wing very difficult and almost impossible; today, however, collectors armed with field-glasses search certain trees for the caterpillars which can often be secured in good numbers without any more difficulty, after they are once located, than that of climbing the tree and cutting off the twig on which the caterpillar rests. By confining these larvae in jars or cages with a sufficient supply of the food plant they undergo their transformation just as well as or even better than in a natural state. In due course of time the butterfly emerges and is thus secured in much more perfect condition than if it had been caught on the wing. As a consequence of the increased supply the price of these species has dropped tremendously during

the last twenty years, many of them being today obtainable at the cost of a few dollars per specimen. The same thing is true of the brilliant Ornithopteras of the Indo-Malay region, those huge butterflies with a wing expanse of from five to eight inches, and whose color is a combination of velvety black with either green, yellow, orange or blue. Fifty years ago in order to secure these species it was necessary for a collector practically to take his life in his hands and penetrate unknown regions inhabited by fierce head-hunting tribes; today, owing to the advance of civilization and the improvement in means of transportation, numbers of the species appear on the market each year; the natives have been trained to hunt for the caterpillars and breed perfect specimens of the insect, and whereas in former years collectors would regard even tattered and torn specimens as almost priceless, today for a few dollars a specimen perfect in every respect may be purchased.

In the Palaearctic region all species of butterflies from Tibet have always commanded a high price owing to the

Many butterflies are easily raised in captivity from cocoons picked off trees

The professional butterfly chaser uses every artifice in order to capture his winged prey. The time-honored net is supplemented by light at night, in order to apply practically the effect of flame on moths. An umbrella is a handy receiver for cocoons shaken from bushes

virtual impossibility of European collectors penetrating into the country; of late years, however, the Catholic missionaries who have succeeded in establishing themselves in this region have been instructed by Mr. Charles Oberthur of Rennes, France, the owner of the second largest private collection of butterflies in existence, in the capture of insects and they in turn have trained

some of their native converts. Through their agency large numbers of species which formerly were of extreme rarity or even unknown to science have been obtained.

Another region which furnishes numerous interesting and highly prized butterflies is the high mountain ranges of Central Asia, the Panier Range and the Thian Shan Mountains. Formerly species from these localities were scarcely known outside of Russian collections, but about eight years ago they began to appear on the market in enormous quantities. A Russian who had been commissioned by the Hagenbecks of Hamburg to secure live specimens of the snow leopard occupied his spare moments and those of his men in the early morning hours by picking the half-frozen butterflies off the flower heads on which they had rested over night. To judge by the quantities he secured by this method the region must have been a veritable Eldorado for the butterfly collector. As a result of his activities several species which formerly commanded a price of from ten dollars to twenty dollars a specimen became an absolute drug on the market and were almost given away.

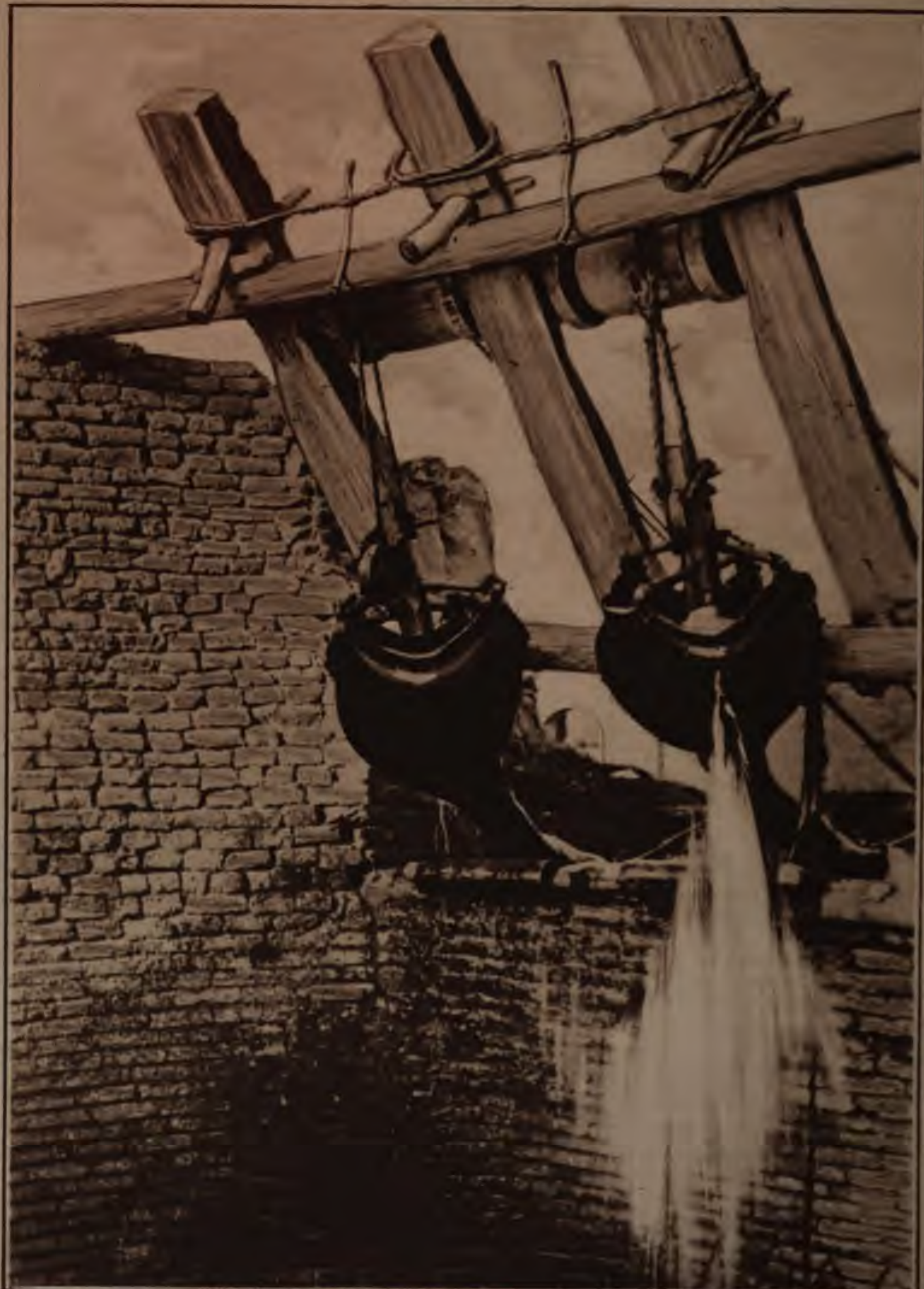
Two Hundred Dollars for a Glittering Butterfly

Of course there still remain some rare exotic butterflies for which possibly a wealthy collector might be willing to pay from one hundred dollars to two hundred dollars a specimen, but such species can almost be counted on one's ten fingers; and it is safe to say that within the next fifty years even the price of these will be considerably reduced, for as soon as collectors become acquainted with their habits and haunts and succeed in breeding them the supply will at once increase.

In our own country, where half the indigenous species of butterflies known to science have been described within the last sixty years, there is probably no species for which more than five dollars a specimen would be paid, and the majority of species could be purchased for less than one-tenth of this sum; the rarest ones are those frequenting the desert regions of the Southwest and the great barren lands of the Far North. The inaccessibility of these regions is again the cause of the rarity, for the very fact that they have remained unmolested in their haunts by man and his civilization is proof enough that at certain seasons they should be found in large numbers.

In this connection, and as an illustration of the contention, the following story is told at the expense of one of the best known private collectors in the country. In the early eighties a collector brought back with him from Arizona two or three specimens of a new species of butterfly which he had obtained at considerable risk to life and limb by climbing some precipitous crags around which they were flying and hanging there by toes and finger nails until an unwary insect came within striking distance of his net. For years no further specimens could be obtained and finally, after making an unsuccessful trip to Arizona in search of the species our collector let it be known throughout the district that he would pay two dollars a specimen for all caught and brought to him. Imagine both his delight and consternation when a native son arrived one fine morning with over one hundred specimens of the long sought species which he had captured with the greatest ease congregated around a moist spot on the ground in some remote canyon. It is said the collector kept his word and purchased the specimens, but needless to say the offer no longer holds good.

When one considers that the number of private individuals willing and able to purchase specimens is very small and that further there are seldom any repeat orders after a small series of specimens has once been obtained, it stands to reason that as a commercial enterprise butterfly collecting is less attractive than selling clocks. On the other hand as a delightful means of spending one's spare moments it cannot be too highly recommended; the eye is trained to observe, the body is invigorated in the chase, the brain cleared of cobwebs by the fresh, pure, country air, and finally there is always the possibility of securing a little extra pocket money by the disposal of rare species which one has succeeded in running to earth.



This water lift, still in use on the River Tigris, near Bagdad, is one of the most ancient mechanical contrivances in existence. Inclined uprights, which are lashed together with rope, are fixed near the water's edge, and project above the bank, or over a brick wall, as *is the case* in the illustration. Rude buckets of hide are suspended by ropes wound on a *wooden* windlass operated by crudely-applied hand power

MARVELS OF AERIAL NAVIGATION

Hovering over the battle lines in Europe are battle 'planes of great size. The engines turn over slowly, giving the 'planes a lazy speed of sixty miles an hour. When a machine rises to fight them off a sudden transformation takes place. Powerful engines are switched on, and at tremendous speed the birds of prey rush to the battle, with their guns belching fire

Faster Than the Fastest Express Train

The new Curtiss biplane makes one hundred and nineteen miles an hour

By Carl Dienstbach

On account of its moderate size and its elimination of small exposed parts this biplane has speed and climbing power

THE really formidable problem of the aeroplane of to-day is cutting down the resistance of its structure.

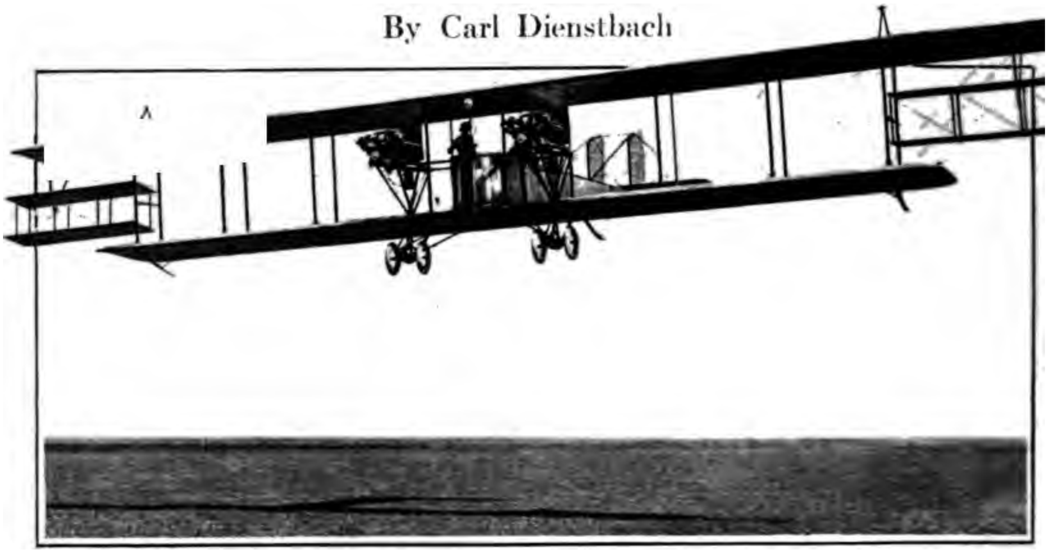
A very meritorious solution of this problem is found in a new Curtiss biplane which has attained speed and climbing power way beyond the usual range of its allotted motor power. The accompanying picture reveals its points of difference. Raking the air by small parts is eliminated more than in any previous design. The new machine shows "smooth bulk" and properly shaped "streamline" (to use a hackneyed and often unjustified expression) from the spokeless wheels and their triangular-shaped "legs." An important exception are the few struts which as triangular frames join the upper plane at its center to the body. There is only one bracing member on each side. This is a bulky strut running from the lower to the higher plane and inclined so as to be compression and tension member in one. Additional bracing is supplied by a similar but even more inclined strut running to the wheel-base. Hence the biplane is stayed like a monoplane, and the design becomes very strong.

As the wheeled base must in any case form a strong downward projection, it should be made thus to serve as a support for the wings and be thereby braced in turn against side strains in bad landings. All vibrating wires may be eliminated in this way, and hence an immense amount of head resistance. The new bulky bracing members do not vibrate. Their number and smooth shape permit the air to flow off easily on all sides without being caught by many adjoining wires and other exposed details, as by a rake. The flaring of the main braces at their ends is necessary to distribute their support over the depth of the ribs. There is one more improvement. A circular hood which revolves with the propeller is placed in front of the radiator. It is open so as to draw in cooling air, but is so designed as to cut down resistance.

The machine offers a very satisfactory solution of the "unsurmountable" problem of carrying much sorely needed wing-surface on an extremely fast racing machine. Former "racers" were the poorest climbers and very dangerous in starting and landing on account of dependence on unduly reduced wing-area for speed. But the new Curtiss racer is useful all around. Its splendid performance—one hundred and nineteen miles an hour—is entirely due to its moderate size. Large machines, on account of inherent relative weakness, are hopelessly dependent on wirebracing.

What's Wrong with Big Aeroplanes

By Carl Dienstbach



A novel feature of the first huge American land aeroplane is the use of biplanes for ailerons. This furnishes stronger control, at the expense of great head resistance

WHEN Curtiss built the "America" for an intended flight across the Atlantic, he was compelled to design a big machine. The radius of action could be extended only by providing for much fuel. Fuel became the most important freight of the bigger machine. Increase of size will not in itself materially increase the radius of action.

For the reason given, the size of the "Americas" and "Super-Americas" is not only such that the radius of action is practically extended across the Atlantic, but a somewhat greater load can be carried. The Allies' lack of fast dirigibles made them eager bidders for the "Americas." But the difficulties encountered in increasing the aeroplane's size must not be lightly dismissed. Accidents now teach their lessons quickly. The first, a very dramatic one, happened in this country when on May 11 last, a "Super-America" for passenger service between Washington and Newport News suddenly turned over into the Potomac, after performing some somersaults, wrecking itself, killing two and injuring three passengers. Similar accidents had occurred in Europe, but they were hushed up for military reasons. So rigid and strong was the large machine that axes could not break through in the effort to get at the victims below the floating wreckage. Yet, a big machine is weaker for its weight than a smaller machine. Very large sailing vessels must be square-rigged, and many small sails must be employed. Aeroplane dreadnoughts ought to be multiplanes on the same principle. This becomes imperative if the fact is considered that aeroplanes were for many years nothing better than death-traps, ready to break in midair and that it was exceedingly difficult to strengthen even the smaller types without making them too heavy. Landing on hard ground is particularly difficult. It means literally a collision with the earth. Huge flying boats are better off, their landing places are abundant and always level and wondrously soft.

But, after the recent accident one feels like asking: Isn't the "America" a somewhat mistaken construction? May success be expected merely by enlarging a successful small model?

A mammoth steamer may get along with proportionately the same size of rudder as a smaller one because it matters little if it takes it many times longer to complete a turn. But in

balancing an aeroplane, there is no time to lose. The huge machine is treacherous because its great inertia makes it apparently stable. But once it yields a little, it tries obstinately to yield more. The necessarily wide distribution of weights around the center of gravity aggravates this inherent tendency. In the light of these considerations the idea of using biplane-ailerons on the first huge land aeroplane recently tried in this country seems interesting, a frank confession that stronger controls are needed, although an excess of head resistance at the wing tips, and objectionable leverage are the price paid for this improvement. The frame that holds the wheels has been strengthened by shortening it, which is made possible by raising the propellers and motors (to clear the ground) although the total length of framing remains the same. There is an advantage in having the lower plane thus laterally brace the length at the point it does. Otherwise the wheels themselves appear weak for a total weight of over two tons and the mass of open framework supporting the motors has undue head resistance; it has the excuse that the motors may thus be brought further ahead to increase the leverage and stabilizing effect of the tail. The weak elevator contrasts strangely with the powerful ailerons and the double vertical rudder.

To find out what really happened to the wrecked "Super-America," we must read the testimony of the tugboat captain who happened to see the accident at close range. The flyers were given no time for observations. Eye-witnesses tell of a propeller working loose and an "explosion" that scattered small fragments before the plunge came. The mere loss of a propeller and the racing of an engine should not jeopardize stability. Probably the pilot, bewildered by the injury to the power plant and handicapped by relatively weak controls, failed to counteract some air disturbance.

The machine also was only one hundred feet up, too close to the water for righting a small monoplane, let alone a dreadnought. The "somersaults" before reaching the water testify to an "America's" lack of stability resulting from lack of leverage between the stabilizing planes and the principal weights which are not concentrated enough and not large enough in proportion to the amount of momentum. All long-hulled flying-boats suffer from such a lack of leverage, with no practical solution in sight.

On a recent trip from Washington to Newport News this "Super-America" fell, killing two passengers and injuring three. So rigid was its structure that axes could not break through in the effort to extricate the victims

Destroyers of the Air

By Eustace L. Adams

An all steel battle aeroplane, manufactured near Boston. These machines may revolutionize the aeronautical industry, since, with proper machinery, they may be stamped out in almost unlimited number. They will doubtless be models for pleasure craft

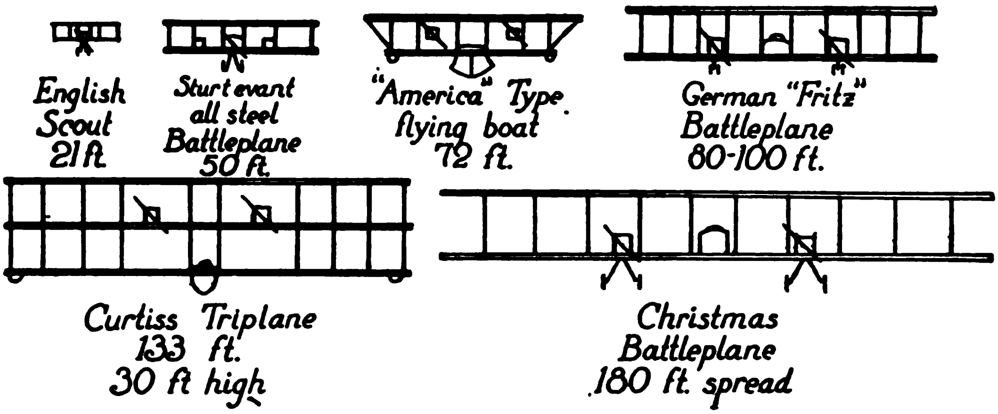
THE navy with the greatest number of super-dreadnoughts wins in a modern naval engagement. Since the launching of the *Dreadnought*, which gave the type its name, the nations of the world have been feverishly engaged, attempting to outdo one another in the building of great sea fighters.

The race for supremacy in dreadnoughts and super-dreadnoughts of the air is as keen at this moment as the race for supremacy on the water. Armies are finding that if they have no giant aeroplanes to drive away the armored battle-planes of the enemy they are fighting under an almost impossible handicap.

France, England, Russia and Germany have all developed their aerial dreadnoughts during the last year of fighting, and the development of the aeronautical industry has progressed the equivalent of many years during the last twelve months, measured by past progress. Those who have seen aviators "loop the loop" and break records at aviation meets and country fairs, can form but a slight conception of the huge machines now hovering over the battlefields of Europe. Giant aeroplanes, heavily armored, and carrying a crew of several men, ward off attacks with two or three guns, shooting high explosive shells in an aerial contest. They are capable of remaining in the air for several hours. Were they devoted to peaceful pursuits, they could carry mail and passengers almost with the certainty and regularity of an express train.

Although Americans have never seen these machines, this country is playing no small part in developing the battle-plane of today and the aerial express of tomorrow. Two builders of aircraft in the United States are reported to be constructing aeroplanes which will be among the largest that the world has ever seen. The average exhibition aeroplane with which most of us are familiar measures about thirty feet from tip to tip. A company with factories in Washington is said to be manufacturing some aeroplanes which have a wing span of one hundred and eighty feet. Heavily armored with steel, and carrying a two-inch gun in each of its two fusilages, each great machine will be driven through the air by two motors developing sixteen hundred horsepower together.

Immediately before the outbreak of the war, the eyes of the world were upon a flying boat named the *America*, built for the first trans-Atlantic flight, but destined to cross the ocean in the hold of a steamship, to play an important part in British operations against enemy submarines. The *America* was one of the pioneers of the present battle-planes. Equipped with two motors, and with a comfortable cabin for the operators, this



Showing the growth of the aeroplane and the comparative sizes of the more important machines now in use or building. The first shown, the scout machine, is very little smaller than the standard size 'planes in use in the United States. Compare it with the others, and an idea may be gained of the great progress recently made in this infant industry

aeroplane was at the time a distinct advance over anything previously built. Under war conditions this machine proved so successful that Glen H. Curtiss is now building them at the rate of one every day.

The *Canada,* a land machine, was the next aeroplane of note designed by Curtiss. Machines of this type are all manufactured in a Canadian factory, and the plans are sedulously kept from the public. Reports from Canada indicate that these aeroplanes have an eighty-foot wing span, and are able to carry two guns and one ton of explosives. Trial flights made at the testing grounds have resulted in speeds but little under one hundred miles an hour, since the machine is equipped with two motors of great power.

The newest designs of Curtiss call for a triplane, with a wing span of one hundred and thirty-three feet. This great flying boat weighs, fully equipped, nearly eleven tons. When on the water it is driven by a propeller similar to those used on large motor boats, but when it is to be lifted into the air, the great power of its two heavy engines is transmitted directly to the aerial propellers, and the huge machine rises like a seagull. A crew of several men is sheltered by an ample cabin, and a number of guns project from the sides of the compartments. The speed of this craft is probably high, and its cruising radius, when fully loaded, should be about six hundred and seventy-five miles.

European War-planes of Huge Dimensions

From the haze of the European war fronts come reports of aeroplanes which transport unheard-of weights for many hours, and which carry large crews to operate machine guns and cannon, but the censors have been remarkably successful in suppressing all definite news of these marvels.

Before the outbreak of war the Sikorsky biplane, a Russian machine of great size, had startled the world by making successful flights with seventeen passengers. Luxurious accommodations were provided for the guests, and meals were served in the air. This machine, while propelled by four Salmson motors of five hundred horsepower each, had the great disadvantage in war times of being slow, since it could fly but little more than fifty miles an hour. Little has been heard of this aeroplane since it was converted into a battle-plane, but it is certain that numerous machines of similar size and design have been added to the Russian aerial fleet, and that the speed has undoubtedly been greatly increased. The luxurious passenger compartments have been remade into cabins for gunners and bomb droppers, and gun mounts now take the places once occupied by comfortable chairs and dining

The Sikorsky biplane, the first of the aeronautical giants of to-day. Before the outbreak of war, this machine startled the world by making successful flights with seventeen passengers

tables, luxuries replaced by explosives.

With the exception of the Sikorsky biplane, the first reports that filtered into the press of both continents concerning aerial dreadnoughts was the appearance over the English lines of a huge German machine, which hovered at a great height over points of vantage, refusing to be driven away by anti-aircraft guns. The engines turned over slowly, driving the biplane at a lazy speed of sixty miles an hour. British aviators who rose to fight off this stranger were received with a hearty welcome. Powerful motors were switched on, and the machine flew to the combat at a tremendous speed. From the fusilage two guns blazed forth, and the hardy British were quickly driven to cover. For some time this machine held the supremacy of the air, and not until France and England built their aerial dreadnoughts did the odds again become even. As nearly as can be ascertained, *Fritz*, as this new machine was soon christened by the English, has a wing spread of between eighty and one hundred feet. In the central fusilage are mounted two heavy guns, and there are accommodations for two gunners and a pilot, with usually an observer to watch the enemy's lines. In two fusilages on the wings are two heavy motors, with the necessary room for mechanicians and engineers. The great power of the motors gives the battle-plane wonderful flexibility of speed.

Scene in the Curtiss factory at Buffalo. Mechanics are seen working on one of the many aeroplanes of the "America" type, which are being turned out at this factory at the rate of one finished machine a day

Unsubstantiated reports from Europe credit the Germans with a new triplane which carries a crew of twenty men, eight motors, and five guns, including an anti-aircraft gun throwing high explosive shells of heavy caliber. This super-dreadnought is said to be sheathed with armor.

Destroyers of the Air

By Eustace L. Adams

The first real aeroplane squadron of the United States Army, consisting of eight one hundred-horsepower Curtiss tractor biplanes. These machines are good American designs, showing European influence in the streamline fusilages, disk wheels and other details

EVEN before the advent of *Fritz*, the great German biplane, which for a brief time drove its adversaries from the skies, the Allies were working upon the plans for aerial battleships. One of the results is a French biplane with a wing spread of about seventy feet. Her wings tower thirty feet from the ground; her crew numbers twelve; her guns are two, and they throw three-inch high-explosive shells. By reducing the crew a great number of heavy bombs may be carried. The new machine is a welcome addition to a bombing foray over German territory. This battle-plane has held its own with *Fritz*, and is accredited with having done much damage during the recent French raids on Freiburg and German towns of military importance.

Twin-engined machines are now common on both battle lines. Machines with two guns no longer arouse interest. Aeroplanes mounting a single gun and one motor are scouts, for the most part, which need great speed and slight armament. A speed of well over one hundred miles an hour is not at all unusual for these machines, which correspond with the swift "destroyers" of the navy.

To fight off these heavy scouts, battle-planes are required, the best known of which is the German Fokker monoplane, which at first created consternation among the British aviators. This machine is a very high-powered monoplane, resembling the French Morane. The wing spread is very small and the planes are flattened, yet a two hundred horsepower motor is mounted on the fusilage. Speeds of one hundred and thirty miles an hour are said to be attained by this wasp-like machine. A single machine-gun is mounted in the bow, and is operated by the pilot. Owing to the need for lightness of weight, small fuel tanks are carried and the machine does not stray far from its hangar. When an enemy flyer is sighted, a Fokker rises, and because of its superior speed, can maneuver to any position it likes. It usually climbs far above its foe, and then, with engine at full speed, dives straight at its opponent, with its machine-gun blazing fire. The only hope of the Allied aeroplane, taken at a disadvantage from above, lies in a quick, twisting dive, followed by rapid flight for the protection of friendly anti-aircraft guns. The Fokker is essentially a machine for fast, decisive fighting, and because of its almost total lack of inherent stability, requires an expert aviator to operate it. The British, since the disastrous *début* of the Fokker as a fighting machine, are said to have evolved a monoplane which will successfully compete with it.

One of the most important of all these new machines has been built in this country, at Boston, Mass. The Sturtevant battle-plane is entirely of steel, and is a biplane of tractor type built with a remarkable simplicity. The steel con-

Courtesy of Illustrated London News

Capable of accommodating sixteen passengers, or of carrying a heavy cargo of bombs, the Sikorsky biplane was the first aeroplane to be built of gigantic dimensions. At the outbreak of war this machine was the largest in the world, but its usefulness was handicapped by its

struction that has been used consists largely of steel tubing, and the best practice in bridge work and structural engineering has been introduced, for the first time in aeroplane construction. All parts are interchangeable, and with the proper machinery, the aeroplanes can be manufactured in great numbers with great speed and at a very low cost. With this type of construction, machines of great size may be built which will have an unusually large factor of safety and great inherent stability.

The first model of the Sturtevant all-steel battle-plane has a so-called turret (in reality a stationary streamline body) half-way out on each wing. In these turrets may be mounted heavy guns, and in time of peace they may be used for passengers or freight. The first trials of this new machine were most successful, and the designer, Grover C. Loening, former Aeronautic Engineer of the United States Army, has been awarded a medal by the Aero Club of America for his meritorious work.

At the present time, aeronautical designers in America have been hampered by the fact that there is not a dependable aviation motor manufactured in this country to-day. In Europe there has been a great advance in the manufacture of aeronautical motors, chiefly because several automobile manufacturers turned their attention to this phase of the motor industry. Firms with international reputations for motor designing, such as the Mercedes in Germany, the Rénault in France and the Sunbeam in Great Britain, have designed aeronautical motors which are giving the greatest satisfaction under the most difficult war conditions.

Until very lately, the aviation motors made in this country have been manufactured by companies which had little

slow speed—a fault which has probably been remedied by now. The huge size of this aerial craft is shown by comparison with the men standing beside it. Remember that there are some aeroplanes now flying which are even larger than the one here pictured

or no previous experience in motor designing. The Packard Company has designed a promising twelve-cylinder aviation motor, and the Simplex Automobile Company is equipping the rejuvenated Wright Aeroplane with a well-designed and carefully built motor, which in its first tests has justified the hopes placed in it by its designers.

When automobile manufacturers cooperate with aeroplane builders and succeed in developing an aeronautical motor which is as dependable as the automobile motor of to-day, the most formidable obstacle in the path of aviation will have been overcome.

If the war has accomplished no other useful end, it has advanced the progress of aviation many years. In the United States, without the spur of military and naval aeronautics, aviation was regarded as a profession from circus performers, whose main duty was to "loop the loop," and provide thrills for the crowds. Now, with aircraft manufacturers turning out aeroplanes at the rate of sixteen a day, the public is beginning to realize that it is a remarkably healthy infant industry, closely rivaling the unprecedented growth of the automobile industry in its early stages. One of the foremost aeronautical experts in the country recently said to the writer:

"Within one year after the signing of peace between the European powers, the first aeroplane will make a successful flight across the Atlantic Ocean. Very soon aeroplanes will be carrying our mails to inaccessible spots. Shortly after this will come the carrying of passengers on a schedule as regular as that of our Twentieth Century Limited. Many of us will live to see the aerial expresses with many planes, multiple engines, and an enormous carrying capacity, which will take us to San Francisco or even to London and Paris as easily as we can now ride to Kansas City."

War Progress in Flying

By Carl Dienstbach

THE way aeroplanes were flown before the war seems almost ridiculous now, after men have really learned how to fly as the result of war's exigencies. The old way made them an easy prey for anti-aircraft guns and for attacking machines. When it became necessary to dart out of the range of a high-angle battery, which had suddenly revealed its presence with bursting shrapnel, or when only a quick maneuver could prevent a hostile machine from blocking the way home, the old-fashioned, steady, level flyer and slow climber proved a very death-trap.

A German "Taube" in flight. We hear less of Taubes now than we did at the beginning of the war. They were standardized machines, and the war upset all preconceived aeroplane standards

Looping-the-loop, caper-cutting, all the acrobatic performances that attend exhibition flying became normal evolutions. Only excess power for a sudden burst of speed and climbing would avail in a perilous moment.

A fast-climbing machine, which also has the virtue of exhibiting great lifting power in the thin air of high altitudes, naturally vaults into the air easily in a difficult start on rough ground. In a critical landing—when, for instance, the ground, which, from above seems invitingly smooth, turns out to be alarmingly rough—the fast-climbing machine can easily stop its swift descent and leap lightly over an obstacle. By reducing his power while the machine is flying at a steep angle, the pilot may even touch the ground at a very low speed.

Salvation Lies in High Power

A machine thus able to deal with rough ground is most stable in rough air. An aviator fears what he calls a "hole in the air"—a pocket formed by a downwardly-twisting current. Into such a hole he drops in a sickening way because his wings no longer have an upward blast to support them. He saves himself, not by trying to climb out—a useless proceeding—but by *steering downward*, thus increasing his speed and likewise the pressure beneath his wings. "To go up, one must sometimes steer up, at other times steer down," Wilbur Wright told me in his little insignificant bicycle shop in Dayton, Ohio, in 1905, in discussing the low-powered Wright machine.

Evidently the aviator needed power to combat these difficulties. This he obtained by resorting to surplus-powered and reserve-powered machines. There would seem to be no distinction between the two terms, but the difference is this: the surplus-powered machine has a motor which is more than able to make it fly and the excess power of which is constantly used for normal flight; the reserve-powered machine uses its excess only in an emergency.

In the surplus-powered aeroplane, "steering down to keep up" is not a praiseworthy maneuver. A pilot cannot possibly know how far the "hole" or local descending current extends and whether he will not plunge into the ground before he gets out of it. But with the reserve-powered machine, it is otherwise. When it steers up, it goes up—always; and what is still more important, it goes up instantly. The words "goes up" do not apply literally. They should read, "keeps up." A heavy machine cannot go up instantly on account of its inertia, but it can as instantly increase its lift as it can turn on full power and put its surfaces at a steeper angle. To steer down in order to keep up was relatively a *slow proceeding*, because even with the aid of gravity inertia cannot instantly be overcome. But with reserve power there is no need to overcome inertia, and the remedy can be applied at once.

With these explanations in mind, we understand why Europeans speak as they do of some dead officer who "lost his life because he attempted to imitate champions on high-powered machines with a weak machine."

The Germans had drawn somewhat too hasty conclusions as to the best type of a military aeroplane and had standardized it. The French simply enlisted all their current sporting types for army use, types which were inferior in long-range scouting, demanding, as it does, only reliability and sturdiness in normal flight, for which the Germans had provided at the war's beginning. But the French machines were better for aerial fighting, which has about as much to do with steady, normal flying as a free-for-all fight with walking in a procession. The new art of flying had to be learned in aerial duels, just as a boy is taught to swim by the simple process of throwing him overboard.

Maximum strength, minimum weight and least head-resistance are best attained by the aeroplane that has its propeller in front of a boat-body. But the propeller in front impedes observation. It also interferes with the operation of a machine-gun. Biplanes, such as this one, have been designed with the object of overcoming these military objections

This British military aeroplane is of the latest type. And yet how similar it is to the crude, early machines of 1908. There are only two striking outward signs of improvement: the streamline boat-body enclosing everything and minimizing head-resistance, and the solid inflexible appearance of the wings, due to the invention of enamels which strengthen and shrink the cloth covering and make it as smooth on both sides as Japanese lacquer

Daily encounters in the sky prove conclusively enough that flying has been as thoroughly mastered as horseback riding. In neither can any attention be paid to handling the machine. There are too many other very important matters to think about. The machine must respond to any subconscious action of its rider as obediently as a cavalry horse, so that its guidance becomes as much a matter of subconscious action as that of a warhorse. Accounts of air-duels read, in fact, as though fighting aeroplanes were under better control than cavalry horses. To place a shot at close range in these wild swoops, without being hit, can be compared only with fighting a saber-duel while jumping hurdles. The fastest French and British machines were found to be the most formidable fighters. Hence they were imitated (and fatally bettered) by the Germans and Austrians.

And Yet, the Aeroplane Is Unchanged

It is surprising how little the general appearance of the aeroplane has changed during its entire history, in spite of its marvelous development. Only the automatically stable types, distinguished by their backwardly-turned wings and upturned tips are an exception. But the aeroplane is such a simple device (and has been found best in its simplest forms) that the phenomenon is easily explained. There are only two striking outward signs of improvement: the streamline boat-body, enclosing everything and minimizing head-resistance, and the solid, inflexible appearance of the wings, due to the invention of enamels which strengthen and shrink the cloth covering and make it as smooth on both sides as Japanese lacquer.

Maximum strength, minimum weight and least head-resistance are best

Before the war, only two or three machines in an endurance contest, in which perhaps twenty aeroplanes were entered, reached their destination. But now we hear of flocks of fifteen flying from Calais to Karlsruhe on a bomb-dropping expedition and returning safely. Surely the war has taught us much about flying machine construction

attained by the aeroplane that has its propeller in front of a boat-body. Thanks to the tractor-screw the biplane has developed as much speed as the monoplane. It is even preferred, since its greater surface gives more lift in emergencies. Unobstructed vision in front is often so desirable that the propeller is sometimes placed behind the surfaces and the boat-body shortened, in spite of the increased head-resistance and decreased strength of the design with the rudders carried by poles. A beautiful solution of the problem of free vision is obtained in large passenger-carrying machines, with the long bodies of which rudders are integrally combined, two tractor-screws and two separate motors being mounted on both sides of the main body. It is then essential to enclose the motors in separate bodies. In the big German battleplanes, the motor bodies are long and carry the rudders. Even such designs waste a certain amount of power, because a catamaran has always less speed than a single boat. But multiple bodies and division of load across the span of the planes is the only method by which large aeroplanes are enabled to carry many passengers and to exhibit that strength which it has taxed all the ingenuity of the scientific engineer to obtain even in the smaller machine.

Has the Big Aeroplane Come to Stay?

Mammoth aeroplanes are at present a spectacular development, especially in America. But it would be premature to include them in a seriously critical review of the aeroplane of to-day. In the main, they have not yet justified themselves, although some of the big water machines of Curtiss, are said to be in frequent use. But there are no accounts of their performances under very critical air conditions, when their relative lack of strength would be a very serious matter, judging from the experiences of similar smaller machines. What recommended them is not economy of performance (because they carry relatively less per square foot of surface than smaller water machines) but the improved facilities offered for navigation, comfort for long trips, and the advantage that one pilot can transport many passengers. They are also required, whenever a great radius of action is demanded, which can be obtained with aeroplanes only by cutting down the passenger list and carrying more fuel instead. In a small machine, this would mean amputating the alighting gear.

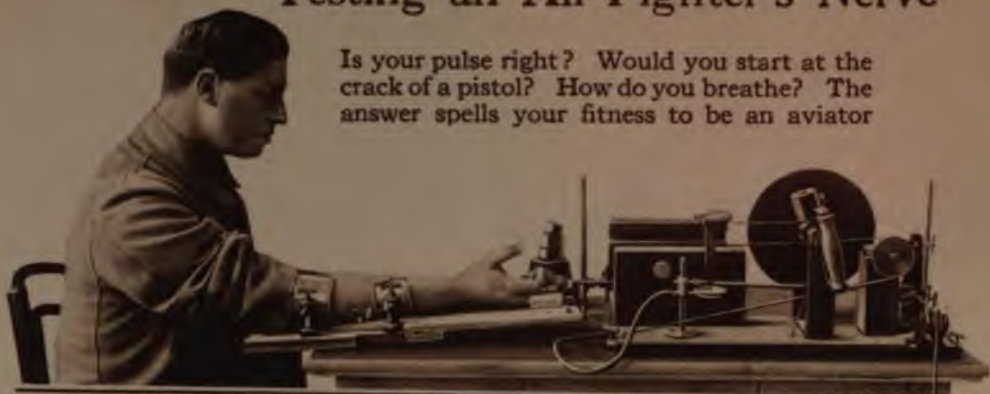
The difficulty of starting and alighting with a mammoth plane is serious. The impact of the heavy mass is too much for its strength, especially for the landing wheels, which have to be made very bulky and clumsy, consequently wasting power in air-resistance. Transformed into a flying boat the mammoth machine becomes more practical, because the hull partakes of all the naval advantages that follow with increased size. Strains to which they are subject from gusts must be formidable. But no technical accounts of their behavior in the air have been published.

Air-fighting is fully as romantic as ever were the deeds of Homer's heroes or Cooper's Indians; for this is the day of personal prowess in air-fighting. We need not dwell solely on the exploits of such German supermen as Immelmann and Boelke (each with a record of at least fifteen victories). Neither superiority of numbers nor of machines cuts much of a figure if it is matched against a certain mysterious personal equation, which cannot as yet be completely analyzed. It may be safe to say that rapid, masterful marksmanship plays in it no small part. It would be indeed a rare coincidence if this ability were likewise found combined with exceptional talents (like Pégoud's) for managing an aeroplane. If that be the case it is obvious that a fighter and flyer in one person must be more formidable than the co-operation of a mere flyer and a mere fighter. We need only imagine two cavalrymen on the same horse (assuming that they could be accommodated together as perfectly as two flyers on a machine) of whom one wields only the lance and the other manipulates the bridle. How should they communicate their respective intentions in fractions of a second?

But this holds good only in regard to small powerful racing machines which fight wasp-like at close range.

Testing an Air-Fighter's Nerve

Is your pulse right? Would you start at the crack of a pistol? How do you breathe? The answer spells your fitness to be an aviator



Above, the ergograph, which ascertains the exact amount of fatigue in the arms and fingers after certain exercises

At left, an indicator strapped to the fingers to determine slight variations in the pulse-beats

THE war-aviator must be so constituted that the sudden menace of danger, of shells bursting about him, of machine-gun bullets raining upon him will find him calm and collected. He must face a crisis not only with deliberate calm, but with the ability to escape with a whole skin.

Polo-players, lion-tamers, big-game hunters proved to be the best aviators in the early days of the flying-machine, simply because they were so constituted that they were not appalled by danger. Indeed, they courted perils. Men of this rare type are hard to find. Besides, every man obsessed with the daredevil spirit does not necessarily constitute the ideal aviator. Even timid business men have their moments of reckless daring. What is wanted is the stuff of which Daniel Boones and Shackletons are made.

But in addition to the daredevil spirit, has the prospective aviator muscular and nervous endurance? After clutching for an hour the control-levers of a speedy monoplane, is his hand firm, or does it tremble? After witnessing a terrible accident, is his heart-beat, his "cardiac rhythm" undisturbed? Is his respiration still normal? Moreover, are his nervous and muscular systems so well balanced and so nicely correlated that his hands promptly obey every external command?

These important questions must be answered in his favor if he hopes to get a job as a war-flier with the French army. The French do not want daredevils to drive their air-machines if they are daredevils and nothing more.

For the purpose of finding out just how favorably every applicant can answer these difficult questions—and he can not answer them with his lips—the French war department employs an ingenious testing machine. Psychologists have known and employed what is called the d'Arsonval chronometer for many years. But it is unlikely that the delicate mechanism has ever been put to such an interesting task.

One part of it tests the pulse-beat. Another determines the tremor of the nerves. Still another registers the respiration. Another apparatus discovers the ability, or the inability, of the applicant to withstand fatigue. After he has

undergone several simple examinations, the candidate is seated in a chair and the final, supreme test is applied.

How would most men act if a revolver were discharged unexpectedly behind their ears? The answer is simple. They would leap into the air; their heart-beat would probably double; they would gasp and tremble as if they had palsy. In so doing they would promptly disqualify themselves as aviators in the French army.

In testing the possibilities of an aviator, various contrivances are attached to the body, all having a definite purpose.

Tubes lead from these devices to a slowly rotating cylinder, on which paper is wrapped. They terminate in points which record the slightest variations in his physique.

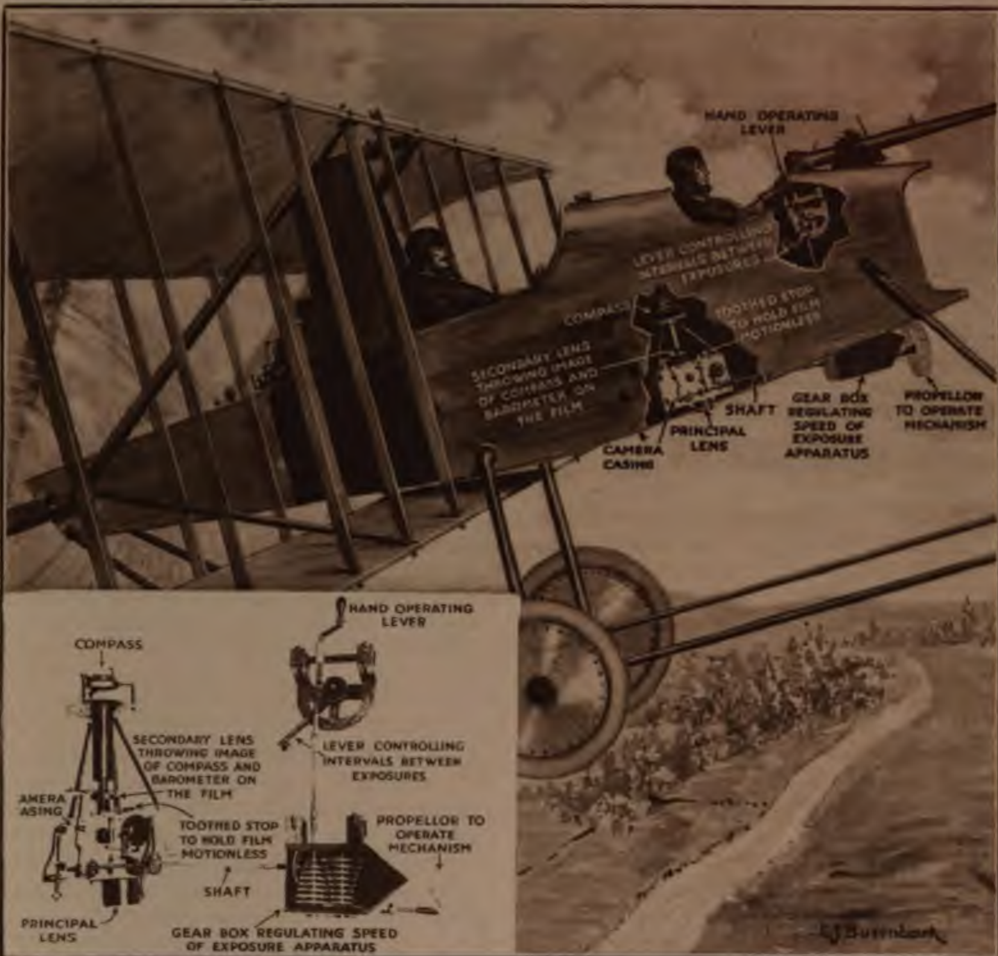
When the clockwork has started and he is perhaps wondering what the queer apparatus is all about, a deafening explosion takes place a foot behind him. The record made at that moment on the revolving paper determines whether or not he is to become a French war-aviator. If his heart-beat, his respiration and his arm nerves and muscles show no undue excitement on the paper cylinder, he goes to work. But if the stylus actuated by his pulse-beat dances about the rotating sheet, he is disqualified. It is only natural that his reflex nervous system should respond in some way to this sudden stimulus; but the man who tests him knows how wide a variation from normal may be tolerated.

Next in importance to the revolver-shot test is that which ascertains the candidate's promptness in acting upon an external command. For example, he is told to press an electric button when he feels a light touch on his left ear-lobe, or when he sees a light flash. His quickness in acting upon these sensations determines whether or not he could meet the sudden contingencies which occur in the air. In a word, whether or not he could handle his 'plane over a roaring battlefield without losing any part of his nerve.

The jagged line on the chart shows the breathing before and after the explosion, indicated by the cross

The d'Arsonval chronometer which records on a smoked paper cylinder the pulse-beats, respiration and nervous tremors of the applicant when a pistol is fired behind him

A Photographic Eye for the Airman



With this camera apparatus every detail of the world below the airman is minutely registered on the roll of film which runs over the camera lens at a speed regulated by the operator

GREATER progress has been made in aerial photography during the present war than in the years following 1858, when M. Nadar, of Paris, took a view of that city by means of a camera attached to the basket of a balloon. The fact that a photograph from an aeroplane of fortifications, damaged railways, bodies of troops, and the contour of the enemy's country gives valuable information which is absolutely reliable, not being dependent for its accuracy on the skill and coolness of the observer, makes this form of reconnaissance of the highest military importance.

Indeed, it is of such value that a dozen different types of aerial photographing apparatus have been evolved in the short duration of the present world struggle. The latest development is found in the Fabbri automatic aeroplane camera, which includes some features already tried out by other inventors but which is, in the main, an ingenious mechanism of original construction. With it an aerial scout can take a continuous photograph of the earth's surface one hundred and thirty miles long. When operated on an aeroplane at an altitude of two thousand feet it will take into its field a strip of ground one thousand two hundred feet wide. In clear weather excellent work

can be done at four thousand feet, in which case the width of the field is about two thousand, four hundred feet.

Suppose a scout is given orders to photograph the entire territory occupied by the enemy. He regulates his camera, soars aloft, and when over the enemy's trenches at an altitude of two thousand feet, for instance, turns a lever which releases a propeller in front of a gear box, which, in turn, starts the camera mechanism in motion. Instantly he obtains a continuous photograph of the earth's surface one thousand, two hundred feet wide.

Should he desire to get more useful information by continuing his flight at a higher altitude, he stops the camera mechanism and ascends to twice the height. There he makes a readjustment of the apparatus and continues his flight, taking a continuous photograph meantime. Mile after mile he continues, until, if he so wishes, he can obtain a photographic record of one hundred and thirty miles of the enemy's territory.

Briefly, the camera consists of a camera box containing two rollers round which the film is carried. The film has a series of perforations along one edge, and a toothed stop is provided to engage with these and hold the film motionless when required. The box is impervious to light, and has a lens pointing downward, through which the main photograph is taken. It has also another lens pointing directly upward, which produces photographs at desired intervals of the exact position of the compass and aneroid needles situated in the holding case above. This last-named photograph automatically registers on the film the direction and altitude of the aeroplane when the exposure was made.

The film rollers are driven by a propeller through the gear box. The hand lever controls the intervals of exposure by varying the speed of the shaft as compared with that of the propeller. The shaft may be operated by hand through the lever and a single photograph be taken, the propeller being for the moment put out of gear.

The ingenious baseball sewing-machine which pulls the covers together and stitches them

A Machine That Stitches Baseball Covers

A SEWING-MACHINE has been invented for stitching together the covers of a baseball. It has a mechanism for holding the ball in position while it is being stitched and pulls the covers together over the ball while the stitch is being taken.

The clamping jaws hold the ball while a wheel above is turned to bring its needle gripping fingers into position to outwardly grip and release the needle which sews the covers. A cam device regulates the needle action.

This can will trap every inquisitive animal that sticks its head into it

Trapping Animals by "Canning" Them

A FIVE-gallon gasoline can cut at the top from corner to corner and with the sharp edges bent inward, constitutes a trap for animals that never fails to work. When the animal enters the can with its head the sharp edges prevent it from extracting it and escaping.

Torpedoing a Submarine from an Aeroplane

BECAUSE an airman flying above the water can sight an underwater craft and detect its approximate depth with the naked eye, inventors have devised a number of bomb-dropping contrivances in an endeavor to make the most of this strategic advantage and place the submarine at the mercy of the aeroplane. One of the most recent of these devices is an aerial torpedo or bomb containing high explosive which when dropped from the aeroplane makes a rapid and straight descent beneath the water and explodes at the proper depth and proximity to wreck a submarine.

The bomb consists of a shell filled with high explosive and into its closed end is fixed a detonator which consists of a tube containing a layer of metallic sodium, a layer of gun cotton and a layer of ordinary fulminate. Attached to the shell is a parachute, which is nothing but a dished circular plate. This acts as a guide in the descent of the bomb from the aeroplane to the water and also regulates the speed of the bomb once it is under water, allowing it to sink slowly.

The cover of the bomb as well as the cap of the detonator-tube are perforated. When the bomb has sunk to a certain distance, water flowing in through these perforations ignites the sodium (a property of sodium), which fires the gun cotton, which discharges the fulminate, which sets off the bomb. These different stages leading up to the actual explosion occur nearly simultaneously, but should they fail—that is, should the unforeseen happen and the sodium not ignite, an electrical igniting mechanism is provided which will discharge the fulminate.

Within the shell there is a dry battery connected to a contact point and to one end of a platinum glow wire embedded in the fulminate. The other end of the glow wire is connected to an insulating lever carrying a contact point. This lever member is a closed hollow tube containing a little mercury, which, flowing to the lower end, tends to keep the lever down. A tube in the perforated cover contains a bucket filled with a dry sponge.

When once the bomb has struck the water and the sponge has sufficiently absorbed it, its weight bearing on the end of the lever member raises this lever into contact with the terminal, thus completing the circuit and discharging the fulminate.

There are several very obvious objections to a bomb of the type described. It is very difficult to hit an object on the ground when the aeroplane is very high. Indeed, no satisfactory instrument has thus far been invented to drop bombs from great heights with anything like the precision that marks the firing of projectiles from great guns. If the aeroplane is to destroy a submarine in the manner proposed, the bomb-dropper must be very near its target—so near that it would itself be in danger from gun fire.

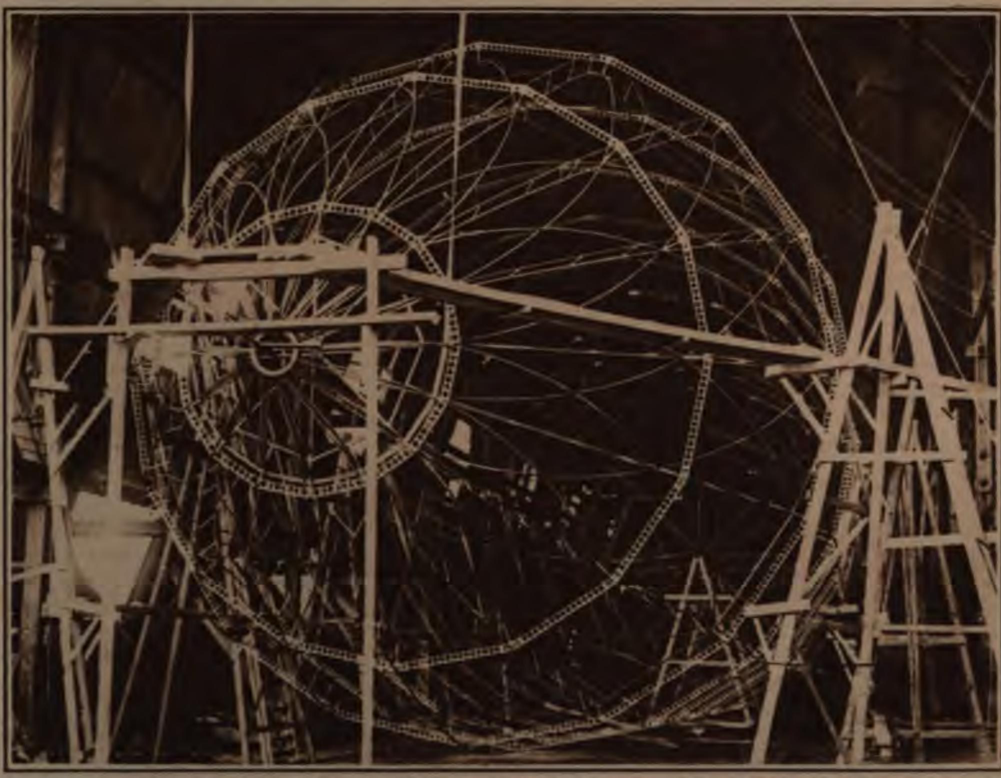
Some of the difficulties of dropping bombs accurately spring from the fact that an aeroplane moves through the air at a rate of at least forty-five miles an hour. Allowance must be made not only for that forward movement, but also for the movement of the submarine as well as for the wind. A hit would therefore be almost a matter of luck.

The airman is monarch of all he surveys — including the enemy submarine submerged thirty to forty feet under the water which is perfectly visible to him. He releases a bomb which is guided in its descent to the water and its speed under the water by the parachute, which is a dished circular plate. Two means are used to explode the bomb. Water flowing in through perforations either fires a quantity of sodium which in turn discharges the fulminate, or it completes the circuit of an electrical igniting apparatus setting off the bomb

A Pigmy Zeppelin

A PIGMY Zeppelin (pigmy as Zeppelins go) with a basket-work frame of layered wood has been recently built for the British Government by a number of American constructors, including T. Rutherford MacMechen, president of the Aeronautical Society of America, and Walter Kamp, a prominent American aeronautical designer.

One of the chief efforts of the designer has been to reduce the weight of the hull and car without sacrificing strength, and this has been accomplished, he believes, by the substitution of laminated wood for the aluminum which composes the framework of the Zeppelin. The rings which are used to keep the hull in cylindrical form are made of thirty-nine thin layers of mahogany, carefully glued together, and covered by a steel collar. Thirty-two wooden ropes, hardly as thick as a man's thumb, wind again and again around the hull, weaving the whole



A pigmy Zeppelin which is being built for the British Government by a company of American constructors. The framework of this novel airship is made of ropes and laminated wood, so closely woven together as to resemble a huge mesh of wood and wire

into a great mesh of basket-work. Sixteen slender members form the longitudinals, running from bow to stern, and intersecting the spirals of wooden rope where they cross each other. The function of the spirals and longitudinals acting together is to distribute the gas lift and strains evenly to all points of the hull.

There are, in reality, two hulls, the inner enclosing thirteen balloonets or gas bags and the outer supporting a waterproof and airtight envelope or skin. Twenty-nine ribs, or transverse girders, encircle the inner hull, and a spider web of wire cables stiffens the alternate ribs and forms the bulkheads between the balloonets.

Two eight-cylinder, sixty-horsepower motors have been installed, and by means of cable drives transmit the power to four propellers mounted high above the car, two being placed on each side of the slender torpedo-like hull.

In hot weather, or when the airship passes through a heated stratum of air, the gas expands, exerting more lifting power, and causing the airship to rise. To control this tendency, the gas has to be artificially cooled, or it will be necessary to release some of the valuable hydrogen to allow the ship to retake its proper altitude. On the contrary, if a sudden wave of cold air strikes the gas bag, the gas immediately contracts, and part of its lifting power is lost. If there is no means for heating the gas and expanding it, ballast will have to be dropped from the car, thus compensating the decreased lifting power of the gas by a lighter weight which it has to carry.

The control of the lifting power of the gas in the MacMechen dirigible is in the heating and cooling process. To keep the hydrogen from cooling and losing its lifting power, hot vapor from the engine is blown into the foot-wide space between the balloonets and the outer skin of airtight cloth. To cool and condense the gas for descent, or to prevent its expansion to an extent that causes an undue inflation of the gas bags, cold air is introduced into the same space by means of a luminum disks with revolving shutters at the bow and stern. *It is claimed that* by this method of construction a rigid airship has been built which is one-third lighter than it is possible to build a Zeppelin of the same relative size. The hull and car weigh 2,190 pounds, and the gas capacity is 108,000 cubic feet, or about one-tenth that of the latest Zeppelin monster. As hydrogen is usually rated by aeronauts, this quantity will lift about three and one-half tons, or seven thousand pounds. With engine equipment and crew, the airship weighs about 5,300 pounds, leaving a margin of 1,800 pounds for ballast, explosives and additional fuel. The length of the hull is 236 feet over all. The designers claim that their airship

will make about seventy miles an hour, or about ten miles an hour faster than the speed of a Zeppelin.

The Popular Science Monthly believes that this airship will prove disappointing to its builders and to the British Government. Previous experiments with wooden frames in dirigibles have proved costly failures. The Zeppelin's first rival, the Schütte-Lanz dirigible, was built with wooden framework, and proved much heavier than a Zeppelin of the same dimensions. Laminated wood was used in the experiment and this was found faulty and discarded. The Zeppelin of to-day is the product of practical experience, as is the second, and successful, Schütte-Lanz, which discarded the weblike wooden frame for the lighter metal ribs and strakes of the Zeppelin. Such a solid frame as that of the pigmy airship would not do for a

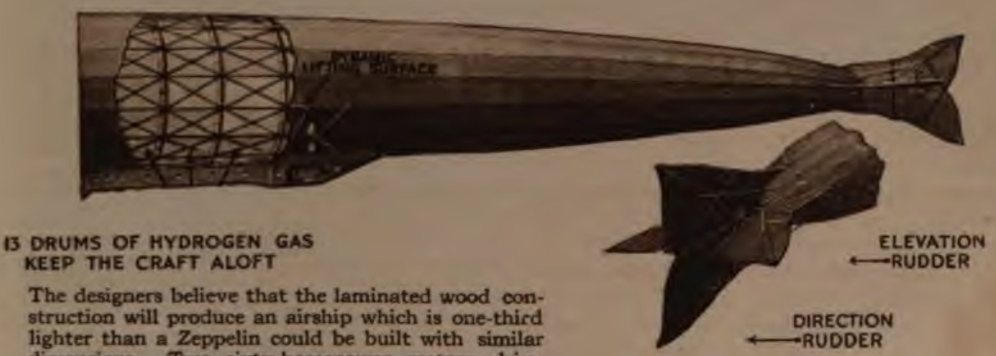
larger dirigible, for it loses the greater lightness for the same strength of a small structure. In a small dirigible resistance against propulsion is so much greater than the lift available for engine power in the large craft, that it completely discounts the small craft's structural advantages. Any improvements in lightness and strength will, therefore, never make this pigmy Zeppelin a superior in speed to its larger and more powerful rival.

The whole idea of a small and speedy "aerial destroyer" is mistaken, since in a dirigible everything has to take second place to speed; otherwise Zeppelins, which cannot seek safety in landing, would be at the mercy of the wind.

The rope drive to the propellers has been proved greatly inferior to bevel gearing, chains and belts. The cable drive was tested on the first Gross-Basenach, but was quickly discarded.

The most meritorious feature of the design of the pigmy Zeppelin is in the alternate heating and cooling of the gases by hot vapor from the engine and cool air sucked in by blowers. This certainly should prove of valuable assistance to the dynamic lift-control without entailing much additional weight.

In conclusion, it seems that the idea of a wooden frame has been tried, approximately in its present form, and found lacking. The rope drive has been succeeded by more efficient means of power transmission, and the entire trend of dirigible construction has been to increase the lifting power, and consequently the size, in order to achieve greater power and speed. Whether the Zeppelin has been a success or not is a mooted point, but the Zeppelin has been the only dirigible that has accomplished anything of note in this war, and the smaller dirigibles have been permanently relegated to their hangars.



The designers believe that the laminated wood construction will produce an airship which is one-third lighter than a Zeppelin could be built with similar dimensions. Two sixty-horsepower motors drive four propellers, and the airship will be expected to make more than seventy miles an hour at full speed

A Barbed-Wire-Proof Fabric

ONE of the most trying tasks incident to trench fighting has been considerably lightened by the appearance in the British trenches of gloves made of a fabric which is said to be impervious to barbed-wire points. The fabric is made up into mittens, with the first finger and thumb separate. The fabric is waterproof, and in addition the gloves are insulated for gripping electrically-charged wires.

The same material is applied to the manufacture of sleeping-bags, which, when opened, may be thrown over a barbed-wire entanglement to allow a soldier to climb over the sharp points without injury. When made up into vests or tunics, the fabric is strong enough to turn shrapnel splinters, or even a bullet when it has lost part of its momentum. The interlining is antisepticized, so that if a bullet goes through, it takes into the wound enough antiseptic wool to prevent poisoning.

The materials used in the manufacture of this remarkable fabric have been sedulously kept secret thus far.

MARVELS OF

MOTION PICTURES

The intrepid hero comes downstairs just off the Jersey shore and finds the Hudson River wallowing in his reception parlor. Fearlessly, at the command of the director, he jumps in the water and ploughs knee-deep through Hoboken mud while the camera clicks

How Movie Men Film Royalties

By Ernest A. Dench

THE filming of royalties presents probably the most difficult task a moving picture camera man can possibly encounter. Kings and queens are zealously guarded, and access to them is had only by long and tedious waiting, if at all. The authorities must be extremely careful, as the trick has already been tried by terrorists of disguising an anarchist as a movie operator. Fraudulent credentials have been used repeatedly.

In England, when a royal procession is held, the route they intend traversing is circulated beforehand. This affords the photographers an opportunity of selecting an advantageous position. Exciting competition for best places results. Operators as a result often seize an advantageous viewpoint and maintain possession by remaining for a night and until the procession passes.

One time, when King George and Queen Mary attended the horse races, the rumor was circulated that the militant suffragists would make an attack on the royal automobile, so steps were taken to prevent every suspicious character from approaching. The police even forbade movie photographers being present. However, the rumor reached the ears of King George, who is an ardent movie fan, and he issued a statement which has become an epic in moviedom.

"Only a few thousands of the millions of my countrymen throughout the world can see the part I play in this event," he said, "but a motion picture can convey it to all my loyal subjects whether they reside in London or Australia."

In Germany, the difficulties are even greater. The operators are asked the most searching questions by the authorities and have to make the best they can of the position, which is seldom satisfactory, allotted to them. They are also required to promise not to export the film without submitting it to be deleted of any military information of any value to an enemy power. At all events, these rules were in force before the war, and in all probability they have since been made severe to a point almost beyond conjecture.

The moving picture as a result of which these stringent rules were made depicted the entry of Emperor William's daughter and fiance into Berlin. This was exhibited at the Berlin theatoriums on the same evening. The police intervened, and all of the copies in circulation were confiscated.

Russia has long been recognized as the home of the iron hand even in times of peace. The Czar values his privacy highly; at least moving picture men find it the height of impossibility to gain an interview with him.

though the moving picture photog-ers are more greatly restricted now in the past, one time, during the of Alexander III, a dauntless op-succeeded in filming the imperial y at three yards' distance, something that has never before been accomplished during a Russian official ceremony.

However, this daring feat was accomplished in the pioneer days of cinematography.

OW FAKE WAR MOTION PICTURES ARE MADE

AR pictures, so we are told by a London correspondent, are even popular in Great Britain than here merica, and the English people are reveling in vivid war dramas which aked on the hillside and the rolling s of the south coast. Clever me-ical devices, the unstinted use of ricity, spring bayonets, gunpowder lers and underground explosives are in the production of grim war pic-, realistic to a degree and bearing armarks of the French and Belgian h and the Polish battlefield.

Agricultural laborers, farmers' sons and village youths, dressed in the uniforms of the British and German armies, are drilled in their new duties and initiated into the mysteries of disappearing bayonets, exploding fake shells, trench warfare and make-believe "gassing." Stroll along a quiet, country footpath bordering some rolling grassland sloping to the sea and you may come upon a horde of yelling men whose spiked helmets and wicked-looking bayonets glint in the sunshine as they charge toward you. If you take cover nimbly and

screen the German soldiers are seen crossing a stream with the enemy shells falling dangerously them. In reality, the columns of water are caused by bladders filled with gun powder, which are ncealed below the surface of the water and electrically exploded at the desired moment.

To the audience the scene is one of a most desperate nature, with the German and English infantrymen engaged in a life-and-death, hand-to-hand bayonet encounter. But the scene loses much of its thrill when it is explained that the bayonets are provided with safety tips and slide against a spring in a tube, when pressed.

watch you will see they are rushing a trench filled with khaki-clad British soldiers. You shudder involuntarily as you see those glinting bayonets sinking into human flesh three or four inches, but you find later that the points are protected with little felt buttons and that they are attached to the barrel end of the rifle by a spring that allows them to retract several inches upon striking a solid subs'ance.

A the soldiers ford a stream in their mad charge, columns of water splash high into the air. After awhile you realize that these columns are caused by dropping shells from concealed artillery. You wonder how it is that all these country "supers" are not maimed or even killed until you find out that the water columns are caused by electrically-exploded bladders filled with gunpowder and hidden beneath the surface of the stream. As the charging "Germans" reach the opposite bank and make straight for the "British" machine guns, terrible explosions occur. They are the shells still "dropping" from the British artillery. The explosions are electrically controlled by a stage director or producer, and are caused by burying small cans of gunpowder here and there under the ground to be rushed. At the proper moment the fake mines are exploded by throwing a switch or pressing a button, thus sending clods of earth, a cloud of smoke and a dummy figure or two into the air. All the vivid effects of a big shell bursting on the ground are thus obtained.

To give to the moving picture patron an idea of the vast numbers of troops now in France, the producers used an ingenious leather band machine, which, in conjunction with a broad window built into the scenery wall, is all that is necessary. The spectators in the theater see women at the window waving out to the departing troops. The tops of rifles with bayonets fixed move past the window and bob up and down in a never-ending stream. Beneath the window, concealed from the spectators, an oper-

a large cast the company must have employed to produce this
showing troops passing by the window! But look at the next picture.

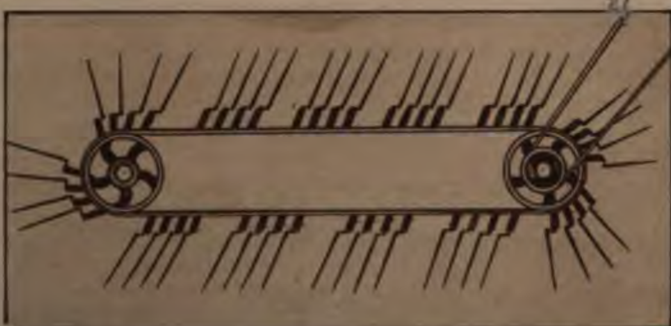
In "close-up" pictures of big explosions, such as bridges, forts and the like, it is not politic for the movie men to get too close; a chance projectile may come their way. To overcome this difficulty the camera is set up in some adjacent spot and focused upon the scene of the explosion. From a safe distance the operator controls his camera by electrical wires, the result being as satisfactory as if he had been on the brink of the scene himself. So excellent are the pictures of modern "warefare" thus obtained by producers in rural Britain, that the motion picture theatre patrons cannot realize that motion picture men are not allowed near the firing line in the theatres of war and that the restrictions imposed on the producers prevent them from obtaining the real thing in France.

turns a leather band passing over fly-wheels about twelve feet apart. ched to the top of the band are rows ayonets. As the handle is turned the nets move along with the realism marching regiment, rifles on shoul- . fastened, as they are, to the leather l which can be moved at any speed.

lotion Pictures Aid in Teaching Students of Agriculture

he Agricultural College of North ota is making extensive use of mo- pictures in the lecture course which iven by the college. A. P. Hollis, the rer, has traveled in past two years with notion picture ma- e and an unusually plete set of reels. e of the films serve raw young men and en to the college, ving the general ac- ies of the campus, s of the buildings, the various phases utdoor construction.

Other reels are educational, showing improved methods of farm cultivation, the detection and prevention of disease to animals and to crops, and other subjects tending to inspire the farmer to greater efforts in efficient farming.



A continuous belt mounted between pulleys and provided with bayonet-like projections furnishes the "army" that is passing by in the above view.

The Secret of the Animated Cartoon

By Eustace L. Adams

WE have been watching a famous "Animated Weekly" for fifteen minutes. We have seen pictures of fires, of disasters entailing the loss of hundreds, even thousands of lives, and of the cruel and heartless World War, until our spirits are at their lowest ebb. Before our eyes French and Belgian villages are wiped out by the struggles of nations, and ambulances carrying maimed bodies flit past, until we feel that the world is all awry.

Suddenly the pictures change. Our old friend, Col. "Heeza Liar," appears and, after a few minutes of ridiculous and absurd gamboling, the world is set right again, and our spirits soar to par.

How is it done? Whose is the skillful hand that can produce this animated cartoon, most popular of screen comedies? Remember that a motion picture film consists of thousands of scenes which are flashed on the screen at the rate of sixteen a second—so rapidly that the eye cannot perceive the interval, with the result that the sensation of continuous motion is produced. Who has the patience to draw thousands upon thousands of pictures which are all thrown upon the screen in so short a time.

Bray has made a thorough study of the producing of animated cartoons in motion pictures and his name is known to the hundreds of thousands who go to the movies.

Seated in his little private office in a great building near Madison Square, and surrounded by volume upon volume on zoölogy, sits J. R. Bray, one of the most famous of motion picture cartoonists. From struggling newspaper artist to head of a syndicate supplying the ever-increasing demand for animated cartoons is the tabloid history of his career.

At the present time Mr. Bray has a staff of six cartoonists, twenty assistant artists and four cameramen constantly at work preparing 1,000 feet of animated cartoons every week. An idea of the amount of work entailed may be gained from the knowledge that there are thirty-four different processes to be undergone by each cartoon, and that there are from three thousand to four thousand cartoons in each thousand feet of completed film. Hence a week's output involves from 102,000 to 136,000 processes.

The accomplishment of this tremendous task is made possible only by a special method which Mr. Bray has invented and patented. As a result of Mr. Bray's invention the work of preparing thousands of pictures is cut in half. When he has decided upon the desired scene for the antics of "Heeza Liar," Mr. Bray first makes a background on a sheet of heavy paper, which background is then printed on many sheets of tracing paper. This done, it is necessary for the artist only to draw the parts which are to appear in motion on the screen. The result is evident. The background remains absolutely stationary throughout the scene, so that the work of the artist is reduced to a minimum. If a man is to be represented as standing still for any length of time, he is printed on the sheets. He does not have to be drawn again until he is supposed to move.

This permanent background may be easily erased or drawn over. What is more, a large number of copies are printed with portions of the background omitted. This obviates the necessity of erasing to a great extent.

In order that movements may be both steady and continuous on the screen, great care must be taken in the drawing

of the cartoons, a task greatly simplified by Mr. Bray's use of tracing paper. The artist merely places a piece of paper upon the last drawing, so that the position last taken by the figures shows clearly through the paper. Thus he is able to draw in the next position carefully and easily.

Mr. Bray supervises personally every stage of the work. He originates the plot and makes from six to a dozen sketches of the vital points of the story. Then the real work commences. While the cartoonists do most of the sketching, Mr. Bray draws practically every movement. If a man, for instance, who has been motionless for some time, is required to raise his arm, the staff cartoonists draw the figure, but Mr. Bray draws the arm in the act of moving. When the sketches have been made, they are turned over to the staff of assistant artists who complete them, drawing them in ink and filling in the color.

To reduce the effect caused by the projection of much white light on the screen, Mr. Bray has invented and patented a process for making a uniform background. By this method one painting of the background suffices for the entire reel.

When the set of cartoons is completed four expert cameramen photograph them to obtain the negative film. An important feature of Mr. Bray's invention consists of a method for controlling the speed of action in the picture. This is done by varying the number of photographs taken of each cartoon. For instance, if the scene demands that an object shall move rapidly, then slowly, and finally come to a stop for a moment, the pictures representing the quick action would each be given one exposure. As the movement of the object diminishes in rapidity, each picture is given a correspondingly increasing number of exposures. When the action comes to a stop numerous photographs are taken of the same picture, the number being dependent upon the length of time that the action is suspended.

Two strips of typical animated cartoons produced by J. R. Bray

Behind the Scenes of a Motion Picture Play

By Loring Brent

ONE of the greatest differences which exist between the speaking stage and the motion picture studio is the matter of temperament. The stage will always be characterized—as it has been characterized throughout its traditional past—by temperament. The motion picture studio, because of the factory ideal toward which it is tending, may not be temperamental. Thus, at the Essanay studios, where I saw the filming of "The White Sister," featuring Viola Allen, factory schedules and factory rules are enforced. The hours are from 9 a. m. to 5 p. m., with time out for lunch. There is even a time-clock to prevent the temperament from side-stepping.

"The White Sister" is a long feature film, probably six or eight reels, and it has required many special sets. The work in progress on the morning of which I write, illustrated an interesting phase in the making of long feature plays, or plays of any length, for that matter—the filming of "flashes." A "flash" is a very short scene which is thrown on the screen for a few seconds to indicate usually the development of a minor plot. It may show, for example, the neglected wife of an absorbed business man enjoying herself at a cabaret, while the main theme of the play—her husband in some financial venture—occupies the long scenes. The brevity of flashes indicates their relative unimportance. Nevertheless, the production cost of flashes is often greater than that of longer and more important parts.

The scenes which traced the major theme of "The White Sister" had been completed; the flashes alone remained. One of these, a private room in a hos-

Above: A log cabin erected for a motion picture play. While in the film shown to the audiences the cabin appears as a complete dwelling, it is in fact but a front only.

Below: The "lake" in back of one of the leading motion picture studios is barely twelve feet in diameter. Yet on occasions it serves for scenes representing large lakes or rivers!

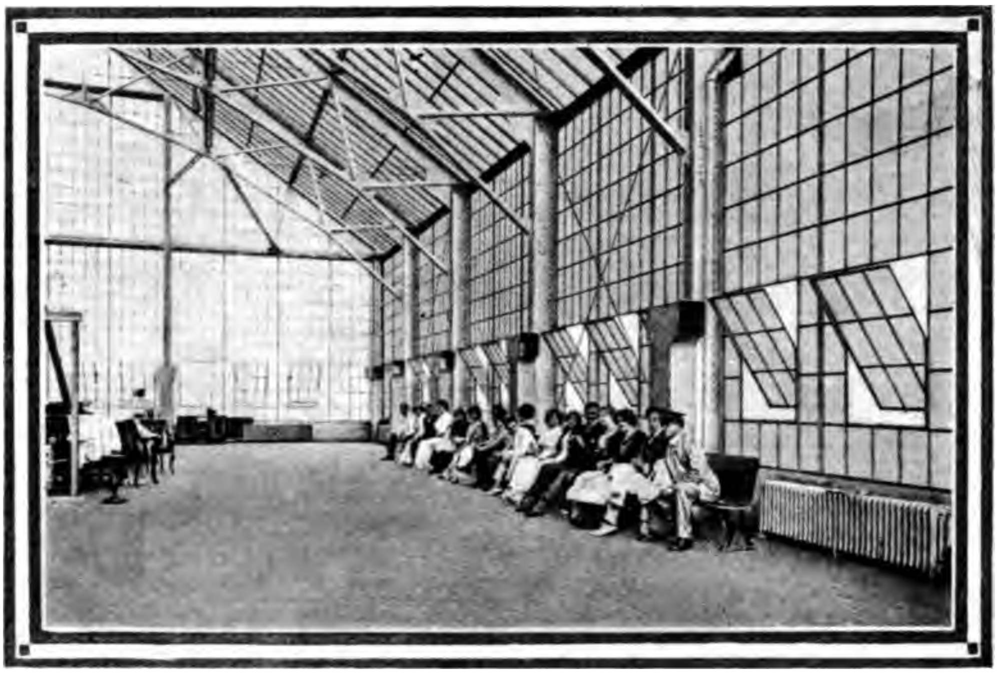
pital, was being filmed. Six times at least Miss Allen, at high dramatic pitch, went through the rehearsal before the camera crank was turned. Although the flash would consume at the most thirty seconds on the screen, the time required for perfecting it amounted to at least three or four hours.

Trolleys For Lighting

"The White Sister" was produced in one of the largest artificially lighted studios in America. The method of lighting is as interesting as it is efficient. Long rows of mercury-vapor arc lamps are suspended from the ceiling on trolleys, so that their light can be thrown upon a scene by merely pulling long cords which run over pulleys and down the side walls. The lights receive electric current through trolley wheels from copper trolley wires above them, just as a street car derives its energy from the wire overhead.

All scenes are illuminated by the greenish light from the long glass tubes. The faces of the leading characters are intensified, and attention thus drawn to them by the concentrated rays of flaming arc lamps. Precautions are taken that a player does not face these lamps any longer than is absolutely necessary; they are almost blinding in brilliancy. Once an actor was compelled to stare for a certain dramatic effect directly across a set of these lights into the face of the "villain." He stared too long, and lost the use of his eyes for several days.

Not every type of actor is fitted for the "movies." A girl may be pretty, a man handsome, yet their features may be of a type utterly unfitted for camera drama. A long or a broad face becomes grotesquely exaggerated. The eyes may be too dull—effective "movie" eyes are usually large and brilliant. Then, too,, the complexion is vitally important. Excessive pallor is grewsomely intensified when it is filmed. High color in patches on the skin appears a deathly black on the screen—and often no amount of paint and powder will conceal the defect; mercury light seems to penetrate directly



The daylight studio of any motion picture producer is an imposing structure from the viewpoint of the layman. It is usually a steel framework covered by thousands of panes of glass.

to the surface of the flesh. Another interesting fact is that some faces "photograph better," as directors say, than

The "back yard" of a motion picture studio contains the most diversified collection of dwellings, vehicles, structures and geographical features imaginable. In fair weather most of the scenes, whether they are "Interior" or "Exterior," are taken outdoors.

others. Some are clearly defined; others are blurred and hazy. No one knows why.

The Queerest of Back Yards

The back yard of the Essanay factory is the queerest place imaginable. In size it measures about two hundred by six hundred feet. In the diversity of its possibilities, it measures more than that number of miles. Standing in the automobile tunnel which leads through the building from the street, you see in a semi-circular sweep of the eye all this: A desert, a "lake," a farm yard, a garage, a section of the Wild West, a fashionable residence, a stockade of the days of '49, a beautiful green lawn, smooth enough for lawn fêtes and tennis, and a curious assortment of old stage coaches, hansoms and "props."

The "lake," which is a concrete basin, is hardly more than twelve feet in diameter; yet it serves its purpose well. A scene may be required showing a man in the act of diving into a river. The camera is adjusted so that the lens covers the water only—not the concrete rim. A soft mattress is tied to the bottom to deaden his fall, the actor dives in—and the camera is stopped. When the story is told on the screen, the water ripples away on all sides of the picture, and conveys the desired effect quite as well as if a river or lake miles in extent had been utilized. On other occasions, during garden scenes, the "lake" serves the duties of a fountain, a pipe connecting it with the water main.

The "desert" is a sprawling pile of white sand. Although there are build-

ings and fences within twenty feet of this sand pile, a camera fitted with an extremely narrow-angle lens is employed for taking desert pictures. A horseman appears in the film as solitary as if he were in the heart of Sahara.

There are some pictures that cannot be "faked," however. Occasionally a scenario is written in which ocean or mountain backgrounds or races of various sorts figure prominently. Such films are carried in stock in large quantities. E. H. Calvin, a director and actor, travels about the country taking "stock" pictures for this purpose. Recently he took motion pictures of the Derby Race at Lexington. The film may not be used for months, but it will lie on the shelves in the stockroom until a play is produced in which horse racing is the background. Bits of the Derby race will be inserted as the plot is developed.

Reality to Secure Reality

On the northwest side of Chicago, fifteen or twenty minutes by the elevated from the Essanay plant, is the blockful of studios and factories occupied by the Selig Company.

Only one studio was in commission when I visited the plant, the others serving temporarily as garages and storerooms. "The House of a Thousand Candles" was being produced in a large glass-covered room. The library scene, which is the center of interest of the story, had just come from the skillful hands of the carpenter. It is worth comment. In the first place it was realistic enough to be truly homelike. The walls were not the patently artificial type usually found in a moving picture studio; they were substantial, and their color was soft. A generous library of *real* books lined both sides of the room. At the end was a fireplace with a genuine fire log, and before it a comfortable leather armchair.

Those who are familiar with Meredith Nicholson's "The House of a Thousand Candles" will recall the secret panels of the fireplace, through which John Glenarm, the old house owner, supposedly dead, made nocturnal visits. I searched for the panels in the fireplace of Selig's "House of a Thousand Candles" for ten minutes before I found them—so perfect was the matching of the boards.

How Actors Are Selected According to Type

The ingenuity and the care exhibited in the construction of the panels and, indeed, the rest of the scenic structure, is but part of the Selig system. A year ago, in the Selig's Los Angeles studio, I was shown a card index system for filing the names of applicants. The actors were classified not by name but by type. John Jones was not John Jones at all: he was merely one of a large number of nonentities listed on cards under the index "English Butler." There were several thousand cards in the file together with the telephone numbers of the applicants. If a society matron is wanted, the director consults the file, selects one of the cards under the index "Society Matron," and requests the applicant to call upon him.

In the wardrobe room at Chicago I saw a similar example of this remarkable methodization. There were hundreds of lockers and drawers arranged in tiers and rows about the room. All were numbered and indexed. If one of the directors wants fifty complete uniforms for a Civil War play, or twenty-five Louis the Sixteenth costumes for a story of the French Revolution, he states his wants to the woman in charge of the wardrobe, and the uniforms or costumes are ready in an hour if need be.

Composing Music with the Aid of a Wax Phonograph Record

Of great aid to music composers is the invention of a Swedish inventor. Connecting with the keyboard of a piano or organ is an electric device which transcribes music as it is composed on a wax ribbon, from which it may be copied. Improvisations are then recorded. The idea is not altogether new. Such an instrument, the invention of a Viennese, has long been installed in the Technical Museum of Munich.

Staging the Celluloid Thriller

By George F. Worts

GOING to the bottom of the sea for motion-pictures was accomplished for the first time about two years ago by George and Edwin Williamson, brothers who invented and perfected an undersea motion-picture apparatus. Their apparatus for making photographs under water was fully described in these pages at the time. But the results they obtained then can not be compared with the results they have obtained in a photo play which has been in process of filming during the past year in the waters of the Caribbean near Nassau, Jamaica.

It Will Be Recalled That the Williamson Apparatus Consists of a Collapsible Tube Suspended from the Bottom of a Barge

Jules Verne and Daniel Defoe on the Screen

They took a most difficult subject for their scenario. It was a composite story based on the most usable parts of Jules Verne's "Twenty Thousand Leagues Under the Sea" and Daniel Defoe's famous "Robinson Crusoe."

When the picture was first contemplated, Stuart Paton, the director, thought that he would borrow a submarine from the United States Navy for the parts of the story in which Jules Verne describes the submarine. The United States Navy was not especially enthusiastic about lending a submarine, and it was discovered that Jules Verne's submarine had very little in common with the submarine of to-day.

Accordingly a submarine was built especially for the picture. It took six months to build, and when it was finished it could dive, rise to the surface and shoot a regulation torpedo. The deck of this unusual craft had one hatch and a very stunted conning tower. In shape only did it resemble the U-boat of to-day. It was engineless. It was submerged by means of inlet valves, and it came to the surface by forcing out the water with compressed air which was carried in tanks. Thirty men comprised the crew. In the bottom of the hull a hatchway (an air lock) was provided, so that the crew in their diving-suits could climb out upon the ocean bottom. The maximum diving depth was about forty feet.

The ocean and its inhabitants provided a great deal of excitement and danger. Most of the time the ocean was rough, too rough for taking pictures. Most of the dramatic action of the film took place on the ocean floor of the Caribbean at a depth of about thirty feet. The water near Nassau was found to be so clear that artificial lighting was not necessary. In the older Williamson undersea picture artificial lights were frequently needed. Since then, however, the apparatus has been considerably improved, and faster camera lenses have also been found.

The Williamson apparatus, it will be recalled, consists of a large collapsible tube suspended from the bottom of a barge. At the bottom of the tube is a camera chamber provided with a window. The camera-man sits with his camera behind this window. In rough weather the barge would roll and the chamber and its occupant would swing back and forth. This motion of course prevented picture-taking. The tides furnished another serious handicap. On

The Twentieth Century Submarine Has Little in Common with the One Jules Verne Imagined; So Six Months Were Devoted by the Wonderful Motion-Picture Magicians to Perfecting One (Illustrated Above) to Fit into the Scenes of the Story. When Finished It Could Dive, Rise to the Surface and Shoot a Regulation Torpedo. It Carries a Full Crew of Thirty Men

In the Bottom of the Hull of the Barge a Hatchway Is Provided, So That the Crew in Their Diving Suits May Lower Themselves to the Ocean Bed. In the Illustration a Diver Is Shown Returning to the Submarine by Way of the Hatchway. Note How Little His Self-Contained Diving Suit Impedes His Movements Owing to Its Very Light Weight

Staged at the Bottom of the Ocean

Above, the Gruesome Spectacle of a Burial at the Bottom of the Sea. The Actors Were Provided with Tanks of Oxygen and Air Enough for Thirty Minutes

Below is Shown the Williamson Cinema Apparatus Which Has Been Greatly Improved Upon Recently by the Inventors to Present a New Photo Play

The Lower Plane Was, in Reality, Stationary Being Suspended by Strong but Invisible Wires Between the Two Cliffs The Upper Machine Swooped Down on the Lower One in Mid-Air, Dropped a Bomb Upon It and Destroyed It

many occasions the actors in their heavy diving-suits were swept out of the camera's range. Other dangers not stipulated in the scenario were provided by curious and investigating giant fish. The divers succeeded in breaking one age-old tradition They found that a shark could be frightened away very easily Another fish, the barracouta, gave them more trouble. The barracouta is long, slim, swift and exceedingly vicious. Barracouta in swarms, or schools, would attack the men, and could be driven away only after a fierce battle.

Love-Making at the Bottom of the Sea

Not only were fights with barracouta and fights between men staged on the ocean floor, but many of the dramatic events of the story took place there. A rubber-clad hero wooed his rubber-clad heroine. A burial took place, and treasure was hunted and found. In fact, as many of the features of Verne's story as could be consistently were reproduced.

The actors were dressed for the underwater scenes in diving-suits, which were provided with tanks of oxygen and air

The Camera-Man Being Directly Under the Hurtling Car, Caught It As It Flew Through the Air. It Came Near Crashing Down Upon Him and a Gathering of Curious Ones, But the Heroine Was Unhurt. Why? For the Good Reason That She Wasn't There

sufficient for thirty minutes' work.

Perhaps the most familiar thrill which finds its way through the flickering lens is the automobile smashup. One of the most thrilling feats in which automobiles have figured on the screen this year took place in California recently, when a motor-car in which the heroine was hastening to her hero, speeded over a broken bridge and leaped through the air to the ground seventy-five feet away. There was really danger in this picture; danger, not for the heroine, but for the man who was turning the camera-crank. The bridge was carefully smashed up previously and the central part taken out. The approach was built up much after the fashion that ski runways are prepared in order that the skiiers will fly into the air when they strike the runway.

The Automobile Was Backed Up a Considerable Distance and Was Pointed Directly Toward the Gap, After Which the Steering Wheel Was Locked and They "Let Her Go!"

In the picture as it appeared on the screen, the girl dashed down the roadway, unaware of the fact that the bridge was destroyed. Indeed, she drove the car at high speed almost to the approach. In the mind of the audience, that car kept on going, with the girl inside, and leaped the gap. In reality, she got out of the car when she had stopped it at the bridge approach. Then the car was backed up a considerable distance down the road, it was pointed, or aimed, directly at the bridge and the steering wheel locked so that the car would not swerve. It was started—gained speed, dashed out upon the bridge, hurtled over the gap and came crashing down to earth very much broken up. The camera-man, being directly under the hurtling car, caught it as it flew, meteor-like, through the air. And it nearly crashed down upon him!

The car flew seventy-five feet. It just happened to alight right side up, so that the girl might just as well have stayed in. But that would have been contrary to the new code of thrills which the industry (shall we say "art?") has adopted—Let thrills be as they may—safety first.

Sacrificed to Make a Motion-Picture Holiday

A motion-picture company recently "staged" a costly picture in which one aeroplane swooped down upon another in mid-air, dropped a bomb and destroyed it. While the lower plane which was two hundred feet above the ground, seemed to be moving at a fairly high speed, in reality it was stationary, being suspended by strong but invisible wires between two cliffs. It seemed to move because the movie camera was mounted on an automobile which was moving rapidly below it. The narrow focus of the camera lens prevented either of the cliffs from being shown.

The feat is interesting also for a tragic reason. When the airman in the upper plane dropped the bomb, he was directly above the destroyed plane. The explosion forced an air wave upward which unbalanced the moving plane, it toppled over and the aeronaut was crushed to death in his fall.

Catastrophes by the Foot

TO paraphrase the words of a well-known humorist, there is motion-picture realism and, on the other hand, there is motion-picture realism. There is cinema realism which consists mainly in cheap and unconvincing illusions. Into this class falls the director who substitutes a miniature dreadnought in a bathtub for the real article, or the director who mounts his camera on a rolling platform, this device giving to the steady deck of a ship the appearance of rolling and tossing. On the other hand there is the director who will command his players to leap real precipices on horseback. He is the same director who will sink a company of players with a stretch of nailed-down scenery on a floating dry-dock. This type of director is the man who is giving the public its most shivery thrills.

Sinking a "set" on a floating dry-dock has been done more than once. In fact, it is a favorite trick. A stateroom of a ship is built of wood strips, painted canvas and a porthole. It is erected on the platform of a floating dry-dock and the camera adjusted. The action, dramatically speaking, starts. The sea-cocks of the dock are opened and it gradually sinks. Water creeps up—the ship is sinking! The cameraman cranks, the actors go through all of the pantomimics necessary to convey the alarming information that the ship is

Would you care to be a motion-picture operator or a motion-picture actor, after this? Would *you* look brazenly out of the picture and care naught for the opinion of the man on the wharf?

foundering. When the water is lapping the handsome chin of the hero and the heroine is getting the life preservers from under the berth—the director shouts, "Cut!" When the scene on the screen shifts from this to a real ship tossing about in a storm, the illusion is vivid and convincing.

The present widespread interest in warfare has occasioned the building of elaborate paraphernalia for making motion-pictures

But action for the director and the actors doesn't stop here. In addition to having the whole Atlantic Ocean dumped into his parlor just as the clock strikes noon, the poor rich actor dons his summer tweed ten minutes later and hurries to another part of town to take part in a staged battle, or "war stuff."

The camera man, under the umbrella on the platform, is busily filming the wooden Krupps as they are Krupping away at the invisible enemy

Here the directors are compelled to resort to whatever alternatives stage carpenters and studio mechanics can devise. One of the latest of these invasions into carpenter shop realism is a successful attempt in imitating the 12-inch siege howitzers employed by the Germans. The huge guns are constructed almost entirely of wood which is supplemented at all wearing points with metal. The guns follow the well known Krupp design faithfully. A recoil mechanism is provided as well as a means for regulating the angle of the gun barrel. The wheels are provided with caterpillar treads to enable them to climb over rough ground. The powder charge used in firing is mixed carefully in the studio laboratory. In making the picture the guns are drawn from the point on the "firing line" by a tractor driven by a gasoline engine.

All that glitters is not gold; all guns are not of steel. These are of wood—perfect imitations of the famous Krupp howitzers

Hazards of Motion-Picture Acting: Real and Faked

By E. T. Keyser

SOME people maintain that a camera will not lie. They are correct. A camera shows exactly what happens; but if you place the wrong construction upon what you find in the picture that is entirely your own fault.

If, in a screen comedy, an automobile proceeds casually to ascend the front of a skyscraper, don't miss the remainder of the reel by rushing to the box office to enquire the make of the machine. Perhaps it has not such a very good hill-climbing record after all. Had you watched the filming of that particular scene you would have observed that a representation of the skyscraper's front elevation reposed flat on the floor and that the automobile traveled over it in the usual manner, while, above it, and with lens pointed downward, the motion-picture camera was recording the fact.

A most wonderful exhibition of athletic prowess, as evidenced by a swimmer's ability to jump from the water to a spring-board ten feet above, was produced by the simple method of having the aquatic Samson run backward along the board and jump off backwards. Then the film was run through the projecting machine reversed, presenting indisputable evidence that the flying fish of the tropics had found a human rival.

Speaking of jumping, have you noticed the effortless manner in which comedy characters lightly vault to the top of a wall which would have baffled the crack pole-vaulter of your old college team? The actor is photographed while making a short jump from the ground. The cameraman ceases grinding while the jumper ascends the wall via a ladder, placed out of range of the lens. Then the actor jumps down. The second "take" is reversed and joined to the first, thereby showing the superiority of knowledge to training.

But it is not in comedy alone that the ingenuity of the cameraman and of the cutter is shown. Nellie, the little daughter of the engineer, wearied by a long day's quest of the elusive buttercup, goes to sleep on the railroad track, with her downy cheek pressed close to a fish-plate. Papa, driver of the crack flier, with the Limited in tow, rounds a curve and sees with horror his angel in the path of the iron monster. To stop the train is impossible. Must Nellie die! Perish the thought. With an agility bespeaking long practice in saving little Nellies, papa climbs forward on his engine, reaches the cow-catcher and, just as its cruel bulk is about to crush out the fair young life, leans over and triumphantly raises his child in his strong right hand and out of harm's way.

Helen Gibson playing the leading role in a breathlessly exciting railroad drama

Before complaining to the S. P. C. C. of the reckless manner in which children's lives are

The cold shudder caused by witnessing a death struggle on the edge of a precipice, with the final thrust which hurls the villain into space, has no basis in fact. Just as he is about to fall, the camera is stopped, a dummy substituted and the action resumed. As soon as the dummy is spattered on the rocks below, the camera is again stopped and the real man assumes the position of the dummy. Mark Swain and Chester Conklin are here shown about to fall from a real aeroplane in this safe but photographically horrible way

When the picture in the circle is viewed on the screen, it will tell the story of a hair-breadth escape from destruction, but when it was enacted, the train was moving very slowly and the daring leap was made with deliberation

Above, a leap for life. This jump was not faked

A wrecked bridge makes a good setting for a film story

Above, a real water scene. Ability to swim and dive is invaluable to the moving-picture actor. In some instances, the "struggle for life" which appears on the screen is not faked. Below, a horrible train wreck from which some cherished heroine miraculously escaped

Above, jumping from a burning building into a net. Below, Pearl White rescued from drowning

In circle, Helen Gibson, former telegraph operator, and Robyn Adair "playing" on a railroad bridge

Douglas Fairbanks has forsaken the regular stage for such dare-devil "stunts" as this

ngered to make a few feet of him, e and watch how it is done. Behold ocomotive with the engineer on the atcher, Nellie in his arms. Observe the train is moving slowly backward that the camera man is grinding ly. Papa lays Nellie carefully down ie track; then walks backward to his When the film, reversed, is run lly through the projector, there will nother thriller on the screen.

. B.—It is now considered advisable se hard coal when doing this feat, a keen observer in the audience noted that the clouds of ke were pouring *into* the k instead of out of it.]

id you ever notice the realis- manner in which a screen or-car will bump its victim? so natural that you would gine yourself witnessing an al occurrence at Fifth Avenue Thirty-fourth Street while traffic policeman's back is ed. There are several hods by which the operation be performed without losing bumpee's services for the picture. The victim lie down in the road, right against the front tires and car is started on the reverse with a most natural jump. Then the cameraman ceases turning while the car is brought to the other side of the prostrate one, with the back of the rear tires touching him this time. Quick throwing of the lever into speed forward produces another jump. The whole performance looks very tragic when it gets on the screen.

Another method is actually to bump and push the victim over and then to pass over him at slow speed with the camera-crank also turning slowly. A rather spare style of architecture is preferred in the victim of this method, as clearances must be carefully considered.

But it is not all trick work, however. There are actors of the screen whose artistic sense or pure dare-deviltry causes them to yearn for a realism which lands them alternately in the Hall of Fame and the hospital.

Some time ago, Irving Cummings worked in a picture which called for a close crossing of an automobile and a railroad train. Picking his crossing, he timed a particular train from a given point to the exact spot selected for the crossing. Then, with a stop watch, he timed his car, from a start from which he could view the train reaching the fixed point. He averaged train and car for several days. At last he made

Helen Gibson makes a safe landing on a horse from a crane on a moving wrecking-train

the dash. There was enough accuracy in his arithmetic to get the crossing but he left part of the rear mudgard aboard the cowcatcher. The engineer, who was the only extemporaneous actor in the event, took a week off at the picture company's expense to recover from the shock.

Not so long ago Anita King, in "The Race" went off the end of a broken bridge and twenty feet out into the water, while an officer was waiting in the Hollywood studio to serve an injunction upon her to restrain her from carrying out the performance. Some one who had received a tip of what was to happen and who feared for the actress's safety had made a strenuous effort to prevent the hazardous leap.

Elmer Thompson has just jumped his car across a twenty-seven-foot gap in a bridge out in Camarillo, California, in the taking of a scene for "The Secret Submarine." The car lighted on the forward wheels with the rear ones elevated like the hind legs of a bucking broncho. It was touch and go whether the machine would somersault or right itself. It happened to do the latter.

In "The Trail of Danger," Helen Gibson is swung by the derrick of a rapidly moving wrecking train, from the saddle of a horse, to the deck of one of the cars.

This combination of cameraman, cutter and realistic actor is responsible for more thrills on the screen than can be found in any three-ring circus, outside of the posters. The life of a moving-picture actor is a series of thrills.

A Camera Which Can Be Tilted At Any Angle

IN photographing natural history objects such as skulls, mounted fossils, etc., it is often necessary to take a view of the specimen as seen from above. In most cases the object can be taken off its stand and placed against a vertical screen with the side to be photographed toward the camera. Sometimes, however, the object is so delicate that one dare not turn it from its upright position, or it is too valuable to risk handling, or it may be altogether too large to do so, as for instance in the case of a dinosaur skull weighing a quarter of a ton or a completely mounted fossil animal.

Sometimes a fossil skull weighs a quarter of a ton; it cannot be lifted to be photographed. That is one reason why this camera was invented

For such cases, there is in use by Mr. A. E. Anderson, photographer to the Department of Vertebrate Paleontology of the American Museum of Natural History in New York, a camera of his own design, which can be tilted at any angle, or, in fact, turned upside down, as shown in the illustration. The camera has a ground glass eleven by fourteen inches and is provided with an unusually long bellows. The stand supporting it is so constructed that the camera when turned upside down can project a considerable distance beyond the vertical axis on which it ordinarily rests.

With the aid of this camera, Mr. Anderson has found it possible to photograph anything which presented itself, whether it was too heavy to be lifted or too delicate to be moved.

Capturing Jamaica for a Film Play

By George F. Wörts

A Moorish city, covering thirty acres of ground, with castles as well as huts, and costing thirty thousand dollars, is but part of the gigantic setting of the new film play

WHEN Annette Kellerman and her large company of players arrived in Jamaica one day last August with the intention of making a moving picture that would cost somewhere in the neighborhood of one million dollars, she found that the entire group of islands was under martial law. Jamaica was heavily garrisoned, all sorts of restrictions were placed upon strangers, and into this unfriendly atmosphere of British colonial red tape came an invading army of actors and actresses, cameramen, electricians, property men, scene painters, directors, and what not. Besides all these there were, of course, heavy artillery in cameras, and the ammunition to be fed to them, tons of chemicals, properties enough to stock the Metropolitan Opera House for a Wagnerian season, and just for good measure an entire menagerie, consisting of lions, tigers, elephants, camels and other creatures calculated to lend Oriental atmosphere when the right time arrived.

Whether or not the estimated cost of one million dollars has undergone the usual press agent's expansion, the fact remains that the picture will be one of the most spectacular that has ever been produced in the whole history of films.

A fair idea of the amount of materials required for the stage settings, costumings, handling of films, etc., can be gained from the knowledge that five shiploads went down to Jamaica from New York the first time. The first consignment of actors, actresses and workmen alone amounted to twelve hundred persons. One thousand tons of properties and stage settings have been shipped.

To insure the proper attention to the cinematographic film, chemical laboratories, storehouses and printing and developing plants have been constructed. An ice plant for chilling the tropical water used in development was erected.

One of the first tasks to which the director in charge, Herbert Brennon, set himself was the construction of the largest stage that has ever been built. It measures over all five hundred by two hundred feet, and is being used for the erection of giant "sets" of all varieties. More than six different companies occupied with different scenes of the film can work at one time.

Probably the most cumbersome task is the construction of an inland Moorish city which covers thirty acres of ground. Contrasted to the usual flimsy structures

used, it was necessary that these buildings be made of durable materials, owing to the destructiveness of the West Indian hurricanes. Thirty thousand dollars is the estimated cost of this city.

Another important feature which will be unique in film history is the storming of the historic old fortress of Augusta. Before reconstruction of this aged ruin could be attempted, it was necessary to make the locality thoroughly sanitary. For putting the fort in presentable shape several boatloads of concrete, stone and steel—all of the stuff of which fortresses are made—were shipped down from New York. It has taken five months to complete the restoration.

A section of the big stage floor, with the executive offices at one side. A portion of a Moorish house may be seen in the foreground

Now that it has been rebuilt, Fort Augusta is to be destroyed and the task of destruction falls to the lot of the West Indian squadron of the British navy. Real powder and real shells will be employed. Needless to say, it required several weeks of persuasion before the permission to stage this battle could be obtained. Before this issue of POPULAR SCIENCE MONTHLY will have reached the newsstands, the West Indian fleet with decks stripped as in actual battle, with gun crews stripped to the waist, with range finders perched in the conning towers, will be bombarding the fortress—and Fort Augusta will have again crumbled into ruins.

Quite as interesting as the construction problems that have been involved is the number of players who will appear in the film. In addition to the twelve hundred actors and "mermaids," there are scheduled to appear ten thousand Hindus who have been held in Jamaica since the completion of the Panama canal, five thousand British cavalrymen and more than five thousand native Jamaicans who have been recruited for the various mob scenes.

The exact nature of the film has not yet been divulged, nor has a name been decided upon. A few of the facts that are known is that besides the bombardment of Fort Augusta, and the use of a Moorish city, there will be a number of mermaid scenes; Trinidad asphalt lake will figure; some of the scenes will take place in the heart of the jungle; and a submarined ship is included somewhere on the programme. Just how consistent the plot will be with all this array of the spectacular, is something for time and the audience to decide.

A Transfer Solution

PRINTED pictures from magazines, newspapers, folders, etc., may be transferred to paper, cloth, cardboard, glass or china with the following solution:

One bar of common soap is dissolved in a gallon of hot water, to which one-half pint of turpentine is added. After it has stood for a night, stir well and bottle. The solution is applied to the print with a soft brush or one's fingers, and the material to which it is to be transferred is placed upside down on it. The back of the material is then rubbed and the design is transferred.

A picture may be transferred to glass for the purpose of a lantern slide. In such a case the glass must be varnished with a perfectly transparent varnish before transferring; then proceed as before. Pictures are transferred to china in the same way.

Expense in Motion Picture Making

By Albert Marple

IT IS indeed difficult for one who is not on the "inside" of the motion picture business to realize the expense to which a picture company will go to secure effects necessary for the successful filming of a photoplay. Sometimes the setting for a single scene costs hundreds and even thousands of dollars. When it is considered that even a one-reel play consists, generally, of something like fifty scenes, it may be readily understood that the cost of producing even a single reel play is enormous. What, then, must be the outlay for five, six and even seven-reel plays? A few months ago the writer traveled with a company during the making of a one-reel play. It took the company four days to put the play on and, although not a single setting was made for this production, the work being mostly outside the studio, that "one-reeler" cost the company about nine hundred dollars. The joke of it was that after being made and finished, that particular play was "pigeon holed" and, for some mysterious reason, was never copied for circulation among the motion picture theaters. This is but one source of the "incidental" expense of a company.

Street scenes cost the most. It is indeed seldom that a scene of this character does not run up into the thousands of dollars. Weeks and months of work will be put upon a street for a single scene. Just as soon as that particular scene has been successfully "shot," down it comes and another "street" rises in its place.

A street scene built for the play, "Terrance O'Rourke" is an exact reproduction of a street in Tangiers, Northern Africa. Employees of the

It took nine tons of powder to make this explosion, the smoke from which clouded the air for two minutes in the resulting motion picture

This "Street Scene in Old London" looks simple, but it was only a little less expensive than transporting the entire theatrical company to London itself. In the circle, a "Master Key" mine scene, all of which was made to order with the exception of the mine dump and railroad on the hill. The Western scenes are naturally less expensive than the reproduction of a European street, but their cost is rather more than would be expected

The Western mining town shown below was burnt at a cost of $1350

picture company combed libraries in search of information concerning Tangiers. After days of labor, assisted by librarians, they found a picture of a Tangiers street. From this photograph, artists constructed the scene. The buildings were made accurately to the scale of the photograph; the fixtures, the rugs hanging from the windows, the awnings, the palms on the roofs, the doorways, and in fact all details of the picture were painstakingly worked up into true dimensions after weeks. A citizen of Tangiers might have imagined himself at home if he had walked down that stage-street. This scene cost the producing company something like fifteen thousand dollars.

One of the most realistic bits of scenery work done by any company is a "mine." When this scene is thrown upon the screen the general opinion is that the "movie" company simply took possession of an existing mine long enough to make this picture. This mine, buildings and all, were constructed especially. It cost the company between fifteen hundred and two thousand dollars. It was built under the personal supervision of an "old timer," and it was done right. It was used in the "Master Key" serial.

A street used in "The Dumb Girl of Portici," one of the longest pictures ever made, consisting of ten reels, cost the company about ten thousand dollars. The cost here named was for the actual material used and the labor of constructing this street. The street took about three months to build.

People who attend motion picture shows are often heard to remark that "all motion picture fires are 'faked.'" That is not always so. In one film plot a fight starts in a gambling house. A bullet misses its mark and sails through a box of matches standing on a shelf. The matches ignite, the flames spreading to the walls of the building and from there along the entire street. This street cost over thirteen hundred dollars to build.

During a storm on the Pacific ocean the schooner, "Aggie," struck a rock and, after being abandoned by the crew, lay for several hours partially submerged beneath the waves. A film company saw a chance for a very unusual scene. The wreck was purchased, and a large company of actors was rushed many miles to the scene. Launches were chartered and several "takes" made. Later a thrilling play was written around these naval scenes, which, alone, ran up into the thousands of dollars.

The foregoing has to do almost entirely with the "scenery" for the pictures, the outlay for actors' salaries has not been touched upon, although it is a gigantic item. The weekly salaries of many stars are written in four figures, and most leading actors receive "several hundred per"—week.

A tool which avoids torn fingers and the still more expensive torn tire casings

Attaching Tires to their Rims Easily

A TIRE tool for quickly attaching the casings of automobile and motorcycle tires to their rims has been brought out. A large U-shaped metal clamp passes from above the tire to the under side of the rim. A lever, with a protruding arm, swings from a pivot in the clamp against the edge of the casing that is to be forced into place. By bearing down upon the clamp, the protruding arm of the lever presses the casing into place inside the rim. A number of small holes are bored in the clamp and the lower end of the lever to adapt it for use with tires of various sizes.

MARVELS OF MODERN CRIMINOLOGY

Shot by His Own Flashlight

The burglar breaks open the desk and flashes his light upon the contents of a drawer. "Bang!" goes a revolver aimed at him from inside the desk. Simultaneously a bell is rung, which awakens the household and sends in an alarm to the police station

These blocks differ in weight and should be arranged the heaviest first and so on down to the lightest

Prisoner doing one of the Bisch-Simon tests. This one consists of placing blocks in a frame; something similar to a jig-saw puzzle. A normal person finds it surprisingly easy; a defective makes an hour's work of it

If the blocks are placed properly they make a man's head. The prisoner is putting the nose where the eye belongs

Science and the Criminal

By Louis E. Bisch, M. D., Ph. D.

The author of this article is one of New York's foremost psychiatrists. He is an associate in educational psychology at Columbia University and director of the Speyer School for Atypical Children in New York. To him we owe New York's interesting experiment of studying the criminal as a human being rather than regarding him as a destroyer of property and life. The new psychopathic laboratory of New York's Police Department has been placed in his charge.—Editor.

IF a seven-year-old child were sentenced to serve a term in Sing Sing, a storm of protest would arise which would reverberate through the country. Yet, in effect, this is what is done. Criminals whose mentality measures only that of a seven-year-old child are made to serve jail terms.

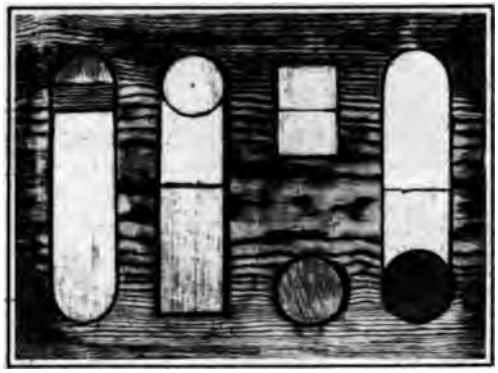
When a normal man commits a crime and is punished for it, the punishment is correctional. When a person of defective mentality commits a crime and is punished for it as if he were normal, the effect is to aggravate his tendencies rather than to correct them.

The primary object of our penal institutions is reformatory. A man of average intelligence, with a normal mind, may be led to see the error of his ways and to mend them through our penal measures. But the man who commits crime because of undeveloped or defective mentality cannot be benefited through any such means. A person who suffers from a mental defect which is curable should be not in prison, but in a hospital. And if his mental troubles are not amenable to treatment, he should be placed in an institution wherein his presence would be permanent, not temporary, and where his criminal tendencies would nor react against society.

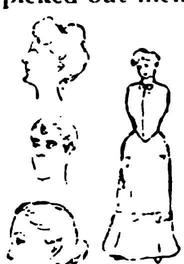
Feeble-minded persons are not benefited in any manner through the serving

of a prison sentence. When they are discharged they are likely to repeat the offense at the earliest possible moment, and society is compelled to foot the bills for their frequent trials and commitments.

When Police Commissioner Woods became satisfied that a percentage of criminals should be dealt with as psychopathic patients rather than as normal men who have chosen to commit crime, he determined to test this idea. So it was that after a certain amount of experimental observation the Psychopathic Laboratory at Police Headquarters came into being.


The blocks must be placed in their proper openings—easy for you, but difficult for a defective

Before the laboratory was finally established we devoted forty-nine days to observations. Each day the prisoners at headquarters are "lined up" so that the detectives may recognize any familiar faces. At these daily "line-ups" we picked out men who appeared to be suffering from some mental defect and gave them a thorough mental and physical examination.


A defective takes time to puzzle out what is missing

During this experimental period, four hundred and nine prisoners were observed. Of this number, fourteen were found to be feeble-minded, one insane, two constitutional inferiors, two drug habitues, one hopelessly immoral, one an alcoholic. Only eight were normal. Out of the twenty-nine selected for examination, twenty-one were found to be defective mentally. Seven per cent of those appearing at the line-up were examined and five per cent were found to be abnormal.

The average number of daily arrests during the period of our preliminary observation was six hundred and twenty-three and the total number of arrests was thirty thousand, five hundred and thirty. We feel assured that observations extending over forty-nine days are sufficiently comprehensive to warrant us in assuming that what we found indicates a condition which exists the year around. And as six hundred and twenty-three is the average number of arrests which take place every day and five per cent of those arrested are abnormal, thirty-one persons who are unbalanced mentally are locked up every day. These prisoners suffer from all sorts of mental ills ranging from dangerous forms of insanity to the pitiful condition of a grown man with the brain development of a child.

Criminals of this type cannot be improved through the ordinary corrective methods. They serve their sentences and return to society only to repeat the offense and pass again through the Police Department, the courts, the District-Attorney's offices back to prison from which they emerge each time more dangerous. This means that they not only constitute a constant menace to society but are a needless expense as well. Their constant reappearance in the courts soon mounts up to a very considerable sum. Also, it goes without saying, prison treatment is far from humane in the case of such persons. Where their difficulty is one which may be cured, they require hospital treatment and where it is incurable they should be committed to an institution wherein they would be protected


A defective finds it difficult to trace the course of this maze with a pencil

against themselves and removed forever from society.

At the conclusion of our experiments, the need for a sure method of detecting the mentally defective among the city's criminals became apparent and so after many conferences with the Department of Correction, Professor Edward L. Thorndike of Columbia University, Chief Justice McAdoo and a number of other magistrates, Police Commissioner Woods brought the Psychopathic Laboratory into being.

Before taking up my duties in the Laboratory, Inspector Faurot and I went to Chicago, where we studied the methods employed in the psychopathic laboratories there. Beside myself we have an expert psychologist, Dr. E. C. Rowe, who works in the laboratory every day. On our advisory board we have Edward L. Thorndike, Professor of Educational Psychology at Columbia, Dr. Frederick Tilney, Professor of Nervous and Mental Diseases at the College of Physicians and Surgeons, Dr. August Hoch, Director of Psychiatric Institute, New York State Hospitals, Dr. Woods Hutchinson, Arthur Train and Raymond D. Fosdick.

We have not confined ourselves to the use of any one particular test or scale for measuring mental ability, but have adapted to our particular needs certain parts of a number of well-known tests.

Every patient receives a thorough psychological, neurological and physical examination. If his case presents any peculiar problems we place it before our advisory board for special study.

Each day we receive a number of unusually interesting cases. I will cite a few at random.

Inspector Faurot turning over a case to the psychologist at the psychopathic laboratory at police headquarters. The inspector, at the right, is handing the history of the case to the psychologist

A physician making an examination of a prisoner at the psychopathic laboratory

A criminal who, because of his intelligence and the number and variety of his exploits, might have been a stage crook was brought in for examination. On the way to the laboratory he told the detective who had him in charge that the scrub woman who was working in the hall when they passed, knew him by name. He believed that the children in the street recognized him and was sure that all Italians did. When examined, this man showed a very high intelligence, but he was suffering from a form of insanity which might, at any moment, take a homicidal turn. From the nature of his calling it will be seen that this man was fearless, yet his insanity had taken the form of abject fear of recognition. His case was incurable. Obviously, prison was not the place for him.

A fugitive from justice was arrested. He had served two terms before, one for assault and one for abduction. Examination showed him to be a high-grade imbecile, his mental age being seven years. This condition is incurable and it is certain that each time such a person gets out of prison he will commit another crime. His ability to reason and his range of ideas were both exceedingly limited.

A waiter was arrested charged with attempted blackmail. He had sent a threatening letter to a company demanding $500,000. When examined, he was perfectly willing to talk about his efforts to obtain the money and believed it was due him. He was found to be insane and the only proper treatment for this difficulty is that which he would receive in an insane asylum.

The most revolting and hideous crimes are those committed by mental defectives. These persons possess an unusual amount of cunning, which makes their apprehension difficult.

X-Rays and the Law

X-RAY pictures have been used as evidence in law suits brought for personal injuries in order to show the injured parts clearly. To mark the negative for identification, lead letters (opaque to X-Rays) have been used, arranged at one side of the part photographed: This method did not eliminate the possibility of fraud, and hence the photographs so marked were not always acceptable to the courts. There was no way of proving that the name and date on the picture were not forgeries. As a result some fifteen States have passed laws which prohibit the courts from receiving an X-Ray photograph as evidence unless the plate or card on which the name, address, date and remarks are written is placed either under or over the parts injured. Suppose the bones of a hand are broken and the fracture is to be photographed. It will be necessary under the law in question, to place a label directly on or under the injured part in order to make the photograph acceptable to the court. The lead letters heretofore used cannot be arranged in this manner: they hide the fracture and thus vitiate the evidential value of the photograph.

To be used as evidence in an accident case, an X-Ray photograph must have a label which could not possibly have been forged

Dr. Aurelius De Yoanna, Brooklyn, New York, has invented and patented a method of authenticating X-Ray plates which will allow him to mark the injured part and arrange a label directly on or beneath the injured part. It is impossible to "fake" the photograph. After the photograph has been taken, the fracture is distinctly seen through the label. Thus the method overcomes the objection to the lead letters heretofore employed, and at the same time the various State laws are obeyed.

The label is so pliable that it may be used on curved parts of the body and in connection with celluloid films or plates. When used with a celluloid plate the label may be placed on the plate or film or on the injured part and the X-Ray taken in the usual manner.

The label itself is made of lead, tinfoil, or any other material opaque to X-Rays, so that when written on by a pencil, pen, stylus, typewriter or other device the writing will become transparent to the X-Rays. Hence, the written or printed matter on the label may be easily read, and the fracture beneath the label carefully studied. This label complies with the law and at the same time does not injure in any way the finished photograph.

The Mechanics of Shoplifting

The department store parasite turns inventor and devises some ingenious tools for stealing under the detective's eye

A capacious repository—a bag sewed inside a coat

A skirt bag large enough to hold a baby grand piano—almost

The false bottom travel-bag—a Hungarian contrivance

FOR sheer cleverness the professional shoplifter deserves the iron cross of thiefdom. He or she (there are just as many men as women in this vocation), must work under the vigilant eyes of detectives. Yet shoplifters ply their trade with seeming indifference, pilfering finery that totals hundreds of thousands of dollars a year.

Although department stores reluctantly admit it, the fact is that shoplifting is as profitable as ever. There are reasons enough The professional shoplifter has his regular customers for whom he steals. The customer selects the article in the store, the shoplifter steals it, obtains a fair price for it—plus his cleverness, and the deal is closed and forgotten. It is purely a business transaction—cash only, and no questions asked. There is no dickering with a "*fence*" or second-hand dealer; consequently the police are thrown off the usual beaten path.

Unfortunately for our stores the professional shoplifter has found time and opportunity to turn inventor. His tools are ingenious mechanical contrivances. One of these is the false bottom, hinged-flap traveling bag, recently found in the possession of a Hungarian team—two young men and a woman.

Innocent looking in itself, the bag is a veritable storehouse for purloined articles. The thief places the bag on the counter over the article to be stolen. By leaning carelessly on it enough pressure is exerted to force the article up past the hinged-flaps into the false bottom. If the thief is apprehended the bag is opened and reveals nothing, unless the searcher suspects that there is a false bottom.

When a thief is caught with the

side-flap suitcase, conviction is almost always sure to follow. However, the contrivance is very effective in stealing ribbons, gloves, handkerchiefs and hosiery. The bag is placed on the floor and the articles are simply rolled off the counter on to the flap as the thief calmy looks the salesgirl in the eye. The flap is returned to its position by the foot.

Then there is the subtle third arm used for over a century—an artificial arm, fitted into the sleeve of the coat, which rests quietly on the counter while the real arm inside the coat is busily tucking away stolen stuff. A woman using this means to steal imported laces was arrested in Philadelphia. The published story of her arrest created a furore.

Often thieves are caught with two roasting pans wrapped in heavy paper under their arms. Of course, the paper is torn underneath and the articles deposited in the pans. False packages are not uncommon. They consist of paper wrapped around a frame. The interior is large enough to hold six dozen handkerchiefs.

There are muffs, umbrellas, long gloves, blouse-bags, skirt-bags, men's pockets with the bottom at the knee line, shoes with false soles, real babies with conveniently long dresses up which valuable are stored, and many, many others.

A shoplifter's sleeve rolled back to reveal the artificial third arm

A bag, sewed in the shoplifter's skirt, filled with all manner of stolen articles

Stealing with a side-flap suitcase. The flap is closed by the foot

The Electric Thief-Catcher

It rings a bell, takes a photograph of a burglar, and shoots him as soon as it sees his flashlight

By B. F. Miessner

ALTHOUGH this apparatus accomplishes some startling results, the idea of selenium-actuated burglar alarms is not altogether new. M. Dafah, a French engineer at Jansac, suggested the use of selenium for this purpose several years ago; others have worked along similar lines.

It may be mentioned here that no attempt has been made to obtain patents on this apparatus; its use is unrestricted, and any one with the inclination may copy this arrangement for his own use or pleasure.

But what is this Electric Thief-Catcher? How can any machine or electro-mechanical contrivance *catch* a thief?

In the first place it does not catch him, if by catch is meant to pursue and seize, and perhaps to march him to the patrol wagon or police station. If by catching is meant to trap, then we may safely say that it does exactly that, and it can be made to do it as effectively as you please. The writer very narrowly escaped being quite effectively caught, when on one occasion this apparatus sent a thirty-two caliber bullet through his coat-sleeve!

By "as effectively as you please" is meant that the "catching" can be varied all the way from merely sending in an alarm, to frightening the intruder away, or actually shooting him dead.

All that is required of the burglar is that he possess a light of some kind, if it be only a match or a pocket flashlight, and that its rays fall upon the acute and ever wakeful eye of this hidden apparatus.

This electrical eye is a selenium cell such as is shown in one of the accompanying illustrations. All that it can do is to record its impressions by sending an impulse to the electro-mechanical brain of the apparatus, when stimulated by a light. That impulse is a surge of electric current when the resistance of the cell drops, due to the effect of the light. The cause of this curious effect is not yet understood but is being investigated by several men, among whom is Professor F. C. Brown, of the Iowa State University.

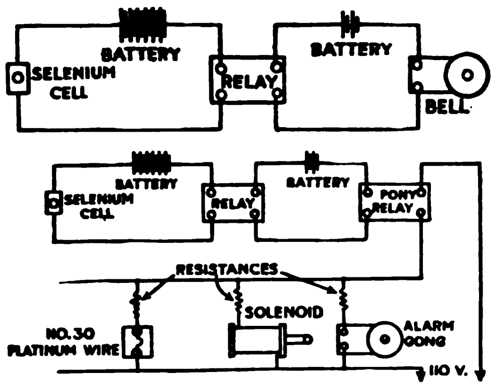
The brain is a sensitive relay, preferably one such as is used in the Electric Dog, which was described in the March number of *Popular Science Monthly*. This brain has the power to stimulate any one or any number of a great variety of electro-mechanical muscles, and to produce a corresponding variety of actions. In the writer's apparatus one of these was an electric gong, the burglar alarm; another an ordinary revolver whose trigger was pulled by an electromagnet; a third was a camera whose shutter was opened by a cord attached to the same electromagnet; a fourth, a charge of flashlight powder, which was set off by the heating of a short piece of fine resistance wire; and on one occasion a fifth was a phonograph with a specially prepared record, which, without a doubt would frighten out of his wits the boldest thief who heard its weird and uncanny warning.

Here, then, we have an electro-mechanical creature, which, hidden from all view, and with no human agency, will fire a revolver, send in an alarm, set off a charge of flash powder, and take the photograph of any marauder who prowls about with a light.

During the course of a lecture before the Chicago Electric Club and the National Electric Light Association, the author in the guise of the burglar stepped up to the platform in the darkened lecture hall, flashlight in hand; the instant the light fell upon the eye, the revolver began firing, the bell rang, the camera-shutter opened, the flashlight powder exploded, and the photograph on the following page resulted. In another lecture a phonograph was used and for five minutes there was enacted the

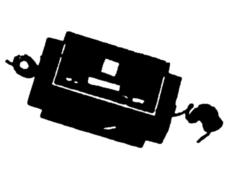
invisible, but by no means silent drama which might follow such a catch in a home. The cursing of the burglar, the screams of hysterical women and crying children, the excited father, and a "drag-him-out-by-the-police-finale" were plainly heard.

The principal parts of the apparatus, which we have called the eye and the brain, are a selenium cell and a sensitive relay; the nervous energy is supplied by a battery of cells, which are connected in series with them as shown in the upper diagram. If only an alarm is desired, an electric bell and battery may be connected to the local circuit terminals of the sensitive relay. This bell will ring instantly when a light strikes the selenium cell, and will continue ringing as long as the cell is illuminated. It may be placed in a sleeping apartment at a distance from the room to be protected, so that the burglar will be unaware of the fact that his light has sent in an alarm. A device of this nature would be valuable for the protection of vaults.



Above: The dry cells connected in series. Below: The plan of the connections when several pieces are to be set off simultaneously

The selenium cells may be purchased from scientific supply houses at a cost of about five dollars each. The relay should be as sensitive as possible; a good polarized relay may suffice but a galvanometer relay is preferable.


The selenium cell is the eye of the creature which when illuminated contacts the relay

The battery should consist of a sufficient number of dry cells (these may be of the small flashlight type) to *nearly* cause the closing of the relay contacts when the selenium cell is in the dark, and when the back spring of the relay is in sufficient tension to prevent sticking of the contacts after the light rays are obstructed. When the cell is illuminated the relay should close promptly, and when the light is removed the back spring should pull the contacts apart without hesitation. In general the larger the number of batteries the more sensitive will the apparatus be, but with ordinary selenium cells the normal current should not exceed a few thousandths of an ampere. If the current is too large the temperature of the cell may rise to the point at which selenium begins to melt; this will destroy the usefulness of the cell.

From the relay, acting as the brain, we may lead connections to whatever apparatus we desire to be actuated when the selenium cell is stimulated by light.

When several pieces of apparatus are to be set off simultaneously, for example the apparatus before described, a connection arrangement, such as that shown in the diagram, should be used. One hundred and ten volts are suggested since this is the voltage of most lighting systems, and because a solenoid sufficiently large to pull the trigger of a revolver will operate best on that voltage without additional apparatus, such as storage batteries. Where several pieces of apparatus are thus controlled it is necessary to use an auxiliary relay, due to the delicacy of the sensitive relay, which cannot break currents in excess of a few fractions of an ampere. An ordinary pony relay of twenty ohms resistance is suitable for this purpose. If the arcing across its local circuit contacts is excessive a condenser connected in parallel with them will be found advantageous. The contacts should be set well apart and considerable tension put in the back spring to counteract the tendency to stick. Re-

sistances are shown in the separate circuits for the purpose of regulating the current.

If the mechanisms to be controlled do not require so much power a low voltage battery circuit may be used instead of the lighting circuit. The resistance of the flashlight wire should be low enough to permit of its heating to a red hot temperature when the current is switched on. To prevent this wire from acting as a short circuit on the other apparatus it should be small enough in size to actually fuse and break its circuit; ordinary fuse wire is not very suitable for this purpose, but fine strands of copper wire may be used in the absence of resistance wire. The charge of flashlight powder should explode within the one second during which the camera-shutter is open.

All of this apparatus may be installed in some hidden container such as a drawer of a desk, or of a chiffonier, or in a recess in a wall.

The selenium cell may be protected from the room lights by so arranging a contact on the lighting switch that, when the room lights are turned on, the power circuit of the apparatus is opened. This will prevent the setting off of the apparatus when the room lights are in use, but will in no way impair its effectiveness in the case of another light when the room lights are switched off. The apparatus may be protected from daylight by some simple form of time switch. A switch of this kind can be improvised easily from an old alarm clock, by fitting the clock with a circular conducting plate which will come into contact with the hour hand during a designated portion of the night. Should it be desired to leave the apparatus untouched for longer periods of time clockwork mechanisms, which will run for the desired period of time, may be used. The revolution of a contact arm once in each twenty-four hours is necessary. A contact arm can be arranged which would cause the thief-catcher circuit to be opened say from five A. M. to seven P. M., or during the daylight hours. Another variation would be to utilize a second selenium cell well-exposed to daylight, which, when illuminated, would cut out the thief-catcher apparatus, by operating a relay connected to a break switch. Such an apparatus would be simple in mechanism and should offer no difficulties to the experimenter.

Field Photograph Kit for the Use of the Artillery

A FEW years ago the Signal Corps undertook the task of developing a photographic outfit that could be carried with a mobile army. After much experimenting a field telephoto equipment was designed which contained everything necessary for developing and printing negatives taken in the field by scouts.

A machine was obtained for projecting lantern-slides in a wall-tent, so that the commanding general could see on a large scale the surrounding country, etc. The telephoto-camera has proved somewhat useful in photographing the location of shots in field artillery work. When set up for developing and printing the kit resembles a suitcase on tripods. Two windows are provided. One admits red light for developing and the other white light for printing. The kit has not yet been adopted as a unit of army equipment.

A machine for developing and printing negatives taken in the field by scouts

MARVELS OF MODERN WARFARE

"Such a machine," says Rear Admiral Fiske, "could start at one end of an army and go through to the other like a mowing machine through a field of wheat, and knock down all the buildings in New York afterwards, smash all the cars, break down all the bridges, and sink all the shipping"

If Battleships Ran on Land

By Rear Admiral Bradley A. Fiske

Five years ago Rear Admiral Fiske read a daring paper on "Naval Power" before the United States Naval Institute. Besides making many predictions, which have been fulfilled in the present war and boldly indicating the strategic value of sea power, he presented a dramatically interesting comparison of the maneuvering ability of a battleship and the mobility of a great army. By the courtesy of the Naval Institute that portion of Rear Admiral Fiske's paper dealing with the energy of a battleship and its imaginary possibilities on land is here presented. Rear Admiral Fiske has revised the abstract and brought it up to date for this article. For comparison with an army, Admiral Fiske has taken the Vaterland as one type of naval unit, because she is the largest ship thus far constructed.—Editor.

ENORMOUS is the power that has come into the hands of the naval nations; but it has come so newly that we do not appreciate it yet. One reason why we do not and cannot appreciate it correctly is that no units have been established by which to measure it.

To supply this deficiency, the writer begs leave to point out that, since the military power of every nation has until recently been its army, of which the unit has been the soldier, whose power has rested wholly in his musket, the musket has actually been the unit of military power. In all history, the statement of the number of men in each army has been put forward by historians as giving the most accurate idea of their fighting value; and in modern times, nearly all of these men have been armed with muskets only.

The control and direction of a moving ship are a very wonderful thing; but the very ease with which they are performed makes us overlook the magnitude of the achievement and the perfection of the means employed. It may seem absurd to speak of one man controlling and directing a great ship, but that is pretty nearly what happens sometimes: for sometimes the man at the wheel is the only man on board doing anything at all; and he is absolutely directing the entire ship. At such times (doubtless they are rare and short) the man at the wheel on board, say the *Vaterland*, is directing unassisted by any human being, a mass of 65,000 tons, which is going through the water at a speed of 24 knots or 27 miles an hour, nearly as fast as the average passenger train. In fact, it would be very easy to arrange on board the *Vaterland* that this should actually happen; that everybody should take a rest for a few minutes, coal passers, water tenders, oilers, engineers and the people on deck. And while such an act might have no particular value, *per se*, and prove nothing important, yet, nevertheless, a brief reflection on the possibility may be interesting, and lead us to see clearly into the essential nature of "directability." The man at the wheel on board the *Vaterland*, so long as the fires burn and the oil continues to lubricate the engines, has a power in his hands that is almost inconceivable. The ship that he is handling weighs more than the 870,000 men that comprise the standing army of Germany.

What Mobility Means

Now can anybody imagine the entire standing army of Germany being carried along at 27 miles an hour and turned almost instantly to the right or left by one man? The standing army of Germany is supposed to be the most directable organization in the world; but could the Emperor of Germany move that army at a speed of 27 miles an hour and turn it as a whole (not its separate units) through ninety degrees in three minutes?

The *Vaterland*, being a merchant ship and not fully representing naval power, perhaps it might be better to take, say the *Pennsylvania*. The weight would

be about half that of the *Vaterland*, that is, it would be nearly twice the weight of the men of the British standing army; and the usual speed would be about, say, 15 knots. But in addition to all the power of the ship, as a ship, or an energy greater than that of 275,000 muskets, she will have the power of all the guns, twelve 14-inch guns and twenty-two 5-inch guns, whose projectiles, not including the torpedoes, fired from four torpedo tubes, will have an energy at the muzzle equal to 750,000 muskets, seven-eighths of all the muskets in the German standing army. Now any one who has seen a battleship at battle practice knows that all the various tremendous forces are under excellent direction and control. And while it cannot be strictly said that they are absolutely under the direction and control of the captain, while it must be admitted that no one man can really direct so many rapidly moving things, yet it is certainly well within the truth to say that the ship and all it contains are very much more under the control of her captain than the German standing army is under the control of the Kaiser. The captain, acting through the helmsman, chief engineer, ordnance officer and executive officer, can get very excellent information as to what is going on, and can have his orders carried out with very little delay; but the mere space occupied by an army of 875,000 men, and the unavoidable dispersion of its units, prevent any such exact control.

In other words the captain of the *Pennsylvania* will wield a weapon more intrinsically powerful than the German standing army; and his control of it will be more absolute than is the Kaiser's control of that army.

Mechanism vs. Men

Now what is the essential reason for the efficient direction exercised by the helmsman of the *Pennsylvania*, and the relative impotency of generals? Is it not that the helmsman acts through the medium of mechanism, while the generals act through the medium of men? A ship is not only made of rigid metal, but all her parts are fastened together with the utmost rigidity, while the parts of an army are men, who are held together by no means whatever except that which discipline gives, and the men themselves are far from rigid. In the nature of things it is impossible that an army should be directed as perfectly as a ship. The rudder of a ship is a mechanical appliance that can be depended upon to control the direction of the ship absolutely, while an army has no such a thing as a rudder, or anything to take its place. Again, the rudder is only a few hundred feet from the helmsman, and the communication between them, including the steering engine itself, is a strong, reliable mechanism that has no counterpart in the army.

The control of the main engines of a ship is almost as absolute as the control of the rudder; and the main engines are not only much more powerful than the legs of soldiers, but they act together in much greater harmony.

Inherent Power of a Battleship

Possibly the declaration may be accepted now that a battleship of 31,000 tons, such as the navies are building now, with, say, twelve 14-inch guns, is a greater example of power under absolute direction and control than anything else existing; and that the main reason is the concentration of a tremendous amount of mechanical energy in a very small space, all made available by certain properties of water. Nothing like a ship can be made to run on shore; but if an automobile could be constructed, carrying twelve 14-inch guns, twenty-two 5-inch guns and four torpedo tubes, of the same size and weight as the *Pennsylvania*, and with her armor, able to run over the land in any direction at 20 knots, propelled by engines of 31,000 horsepower, it could whip an army of a million men just as quickly as it could get hold of its component parts. Such a machine could start at one end of an army and go through to the other like a mowing machine through a field of wheat; and knock down all the buildings in New York afterwards, smash all the cars, break down all the bridges and sink all the shipping.

The Emden After the Battle—Mere Scrap Iron

The German commerce destroyer Emden was reduced to a mere hulk at a range of two and a half miles by the Australian cruiser Sydney. Part of the Emden's crew were on shore and later reached Europe after many wild adventures in tropical lands

The Destruction of the Emden

By Rear-Admiral Bradley A. Fiske

Rear-Admiral Fiske's graphic description of the battle between the Australian cruiser "Sydney" and the German commerce destroyer "Emden," is all the more interesting because it comes from an American naval officer who has distinguished himself by the invention of devices which have done much to improve American gunnery. The frightful havoc wrought by shell fire on the doomed German ship carries with it a lesson in preparedness, as Admiral Fiske points out.—Editor.

WHEN making her last raid, which was against South Keeling, an island of the Cocos group, a few hundred miles southwest of Sumatra and Borneo, and while she had three officers and forty enlisted men on shore, the German commerce-destroyed *Emden* was surprised by the Australian cruiser *Sydney* that had been told by wireless of her presence. The *Sydney* was a vessel of five thousand two hundred tons displacement, had a maximum speed of twenty-six knots and carried eight six-inch guns that fired projectiles weighing one hundred pounds. The *Emden* had a displacement of three thousand six hundred tons, mounted ten four-inch guns that fired projectiles weighing about thirty-two pounds. She had a maximum speed at that time of one or two knots less than the *Sydney*. An action ensued, the results of which are clearly indicated by the photographs here shown. The battle began at a range of about two and a quarter miles; but the range was quickly increased by the *Sydney* whose Captain took advantage of her superior speed

All that is left of the bridge from which the captain and officers were wont t direct the activities of the fast German commerce-destroyer Emden

The bridge reduced by the Sydney's shell fire to a battered wreck

The spar deck of the Emden was torn up by a veritable hail of shell

to secure a distant position, at which the smaller guns of the *Emden* could do the *Sydney* very little harm.

Steel Crumpled Like Paper

These photographs indicate the frightful effect of naval gunnery and suggest the tremendousness of naval power. In naval ships, large guns are installed that can be taken at great speed all over the world, and fired with great precision over long distances, and with great effect. In the photographs, we see great masses of steel, crumpled like paper; we see the ship's side penetrated; we see the bridge from which the Captain and the officers usually directed the ship, an undistinguishable wreck of iron and brass; we see the funnels made veritable scrap-iron; we see the spar-deck torn up; we see the ship itself reduced from the condition of a rapidly cruising man-of-war to that of an inert mass of torn and twisted iron. All this was done in little more than an hour.

Although the *Emden* was not a very powerful ship compared with many others she was nevertheless a strong and well-built vessel, and could not have been wrecked except by tremendous power. The power of armies is exerted for the most part by muskets, which cannot be heavier than single men can carry and by field artillery and siege artillery, intended for use against men and lightly constructed buildings of wood and stone and brick.

A Fourteen-Inch Shell is Equivalent to Sixty Thousand Muskets

The value of a bullet fired from a musket, or of a large projectile fired from a gun, is due to its ability to penetrate the resisting envelope of a man in one case, or a ship in the other case. Naturally, the measure of that power is the energy of the projectile, which energy is dependent on both mass and velocity. As was shown in the November number of the POPULAR SCIENCE MONTHLY, the energy of a fourteen-inch shell fired say from our *Nevada*, is about equal to that of sixty thousand muskets when the projectiles start. But after the musket bullet has gone a little more than a mile, it falls to the earth, its energy reduced to zero, while the fourteen-inch projectile has hardly started. If the *Emden* had been fired at by muskets at the dis-

The Work of an Hour and a Half

It takes tremendous power to destroy a ship of war, as Admiral Fiske points out in his article. If the Emden had been fired at by muskets from the distance at which the Sydney destroyed her, the bullets, if they reached their mark, would have rattled off harmlessly

tance at which the large guns were fired in the battle the bullets would not have reached her.

It would not be possible for an army to carry around on land by any means whatever the big guns of war ships; so that the curious condition has come about that the dangerous sea, which defied for centuries the ability of man to move upon it, except very slowly and over little distances, is now contributing much more than the land to the exercise of his power.

Suppose New York Had been the Target

The destruction wrought upon the *Emden*, of which these photographs give such gruesome proof, has another interest for us, of a character not philosophic, but eminently practical, because it suggests that if this damage could be done to a strong, steel structure, like the *Emden*, what would have happened to buildings, in New York, if they had been the targets instead. And it also suggests what might have been the effect if those buildings had been the targets not of the comparatively small projectiles which were fired at the *Emden*, but of fourteen-inch projectiles weighing fourteen hundred pounds, filled with high explosive, fired from a hostile ship.

The American fleet having been defeated, a single ship carrying guns able to fire projectiles fifteen miles, and protected against submarines by numerous destroyers and by other means, could, in two or three hours, fire into New York from a point beyond the reach of any of our guns, one hundred high explosive shells, which falling on our streets, power stations, subways, elevated railroads and skyscrapers, would make the vicinity of Wall street look like these pictures of the *Emden*.

In these battered funnels and this riddled deck we see the price of slowness; for the triumphant Australian cruiser Sydney was just a little faster than the Emden, whose bottom had been fouled bv long cruising in tropical waters

The End of a Battle in the Air

A few years ago military experts considered fighting in the air an improbability and declared that the aeroplane and the Zeppelin would be useful only for scouting and bomb dropping. Now, battles between aeroplanes are so common that they are seldom mentioned in the dispatches. Aeroplanes as yet have been able to accomplish little against raiding Zeppelins. The anti-aircraft guns are the Zeppelin's greatest enemies, and these Paris and London dare not use lest the projectiles fall back in the streets

The Making of a Submarine Mine

By John Randolph Rexford

A battery of mines electrically exploded. Here is a fiercely graphic illustration of the destructive power which is contained in the comparatively small globe or cylinder of steel whose sowing abroad in the sea is the first duty of the navy and coast defense when war breaks

ORIGINALLY all forms of apparatus designed to explode under water to destroy ships were called torpedoes, but this term is now applied only to the well-known naval weapon. Submarine mines may be divided into three groups:

1. Buoyant mines having a constant depth of immersion.
2. Ground mines which are used in shallow waters and rest on the bottom.
3. Floating mines.

The mines belonging to the first and second groups may be exploded either from land by an electric current or by automatic contact with a ship.

Electrically controlled mines are employed only for the protection of harbors and channels and may be divided into two classes: those which are entirely and those which are partially controlled from land. A mine consists generally of two perfectly watertight metal casings made of suitable shape. One of them is hollow and is intended to act as a float to maintain the mine at the required depth below the surface, while the other one is filled with the charge, which may be guncotton, trinitrotoluene or any other suitable explosive, and the detonator for firing the charge

In coast defense work where electric control is employed, mines are anchored permanently in suitable positions, where hostile vessels are likely to pass over them, and are connected by means of electric cables to the shore. Where mines are entirely controlled from shore, an observer on land can fire any mine or groups of mines by closing the electric circuit the moment his optical instruments inform him that the enemy's ship is over a mine.

Firing an Electrical Mine

Mines which are partially controlled from land are anchored only a few feet below the surface of the water. When a ship strikes such a mine an electric contact is made which sends a signal to the shore station. The observer can then decide whether to fire the mine or not. An advantage of electrically controlled mines is that neutral ships can be allowed to pass over such mine fields in perfect safety. The use of such mines has, however, been considerably reduced, chiefly because salt water is one of the greatest enemies of electrical apparatus and makes it very difficult to maintain the electrical connections with the mine, and also because the permanent location

of such mines could be discovered by spies.

The mines which have been chiefly used in the present war are automatic and mechanical, and are fired when the ship strikes against them.

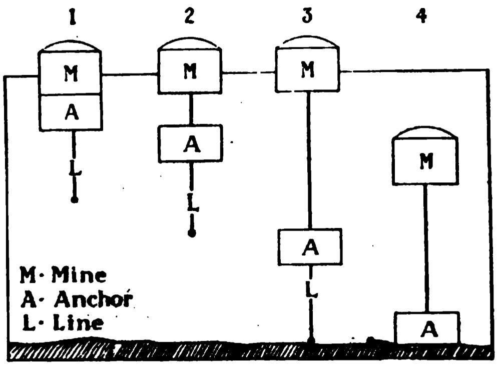
It is by no means easy to design a satisfactory mine which shall have its firing gear carefully adjusted so as to insure explosion of the charge from the slightest shock produced by contact with the passing ship. At the same time provision must be made to prevent the premature firing of the mine either on land, on the mine laying ship, or when being launched into the mine field. Again, it is important that should one or two mines be exploded, the adjacent ones be not fired accidentally—a difficult problem, as the concussion of the water produced by the explosion tends to disturb other mines. Another essential condition is that the depth of immersion under the surface should be constant so far as the rise or fall of tides allows.

A mine consists of three parts: (1) the chamber containing the firing mechanism, the detonator and explosive charge: (2) the flotation chamber to give buoyancy to the mine, and (3) a detachable anchoring chamber provided with a winch having a paying out cable.

A mine is maintained at the desired depth in the water by means of an anchor in which the cable, one end of which is connected to the mine, is unwound from a drum suitably braked and mounted in the anchor casing. The rotation of the drum is controlled by a plumb weight attached to a short sounding line. When the plumb weight reaches the bottom of the sea the rotation of the drum is stopped and the mine is pulled down to the required depth. It is only necessary to determine at what depth below the surface it is desired to anchor the mine and to throw into the water the complete apparatus, namely the mine and anchor, whereupon the whole apparatus will take up its proper position, the depth of submersion being determined by the length of the sounding line.

The diagram on this page illustrates the working of the automatic anchor:

Position 1. After having been dropped overboard the mine is at the surface of the sea with its attached anchor immediately below the mine with the plumb weight hanging about nine feet below the anchor.



Positions assumed by a mine and its automatic anchor in water from the moment of dropping the mine overboard to the final moment of mooring

Position 2. The barrel is unwinding its cable and the anchor is descending to the bottom of the sea owing to the force exerted by the plumb weight in keeping down a lever, so that the drum is free to rotate.

Position 3. The plumb weight reaches the bottom of the sea and the pull exerted on the lever ceases. This lever is now released and locks the drum, so that it cannot pay out any more.

Position 4. As no more cable can be paid out the anchor has sunk to the bottom of the sea and drawn the mine with it. It will be seen from the diagram that the depth of immersion depends on the length of the sounding line.

A safety device is generally introduced which is operated by the pressure of the water. The firing gear is locked by a spring which, however, is counteracted by the pressure of water. When the mine is submerged the firing gear is operative, but as soon as it comes to the surface the water pressure is gone and the mine cannot be fired. The percussion device employed is of the usual type for exploding charges of guncotton and does not differ from those ordinarily used.

The detonator is sharply struck by a ball or a lever when the mine is hit

he ship and causes the main charge xplode.

order to make a mine field as efve as possible loose ropes are somes connected between different mines the object of getting the ship's pror entangled in the rope and thereby ving the mine towards the ship and oding it.

Launching a submarine mine

lines of the type described easily laid. When stowed ly on the deck of a mine-lay- ship the mine rests on the hor which at the same time ns a little carriage to be run ig the deck and simply pped over the stern of the at the right moment.

Vhether mines have actually laid by submarines is, of rse, known only to the naval orities. Patents have, howr, been taken out within the few years for specially designed mines to be laid by submarines and also for providing submarine boats with a series of chambers on each side for holding and launching mines. These chambers are disposed between double walls of the submarine and are made to form a smooth outline with the hull of the boat. This provision makes it possible to carry a double cargo.

Mines Which Become Ineffective After a Certain Period

Unanchored automatic or floating mines must be dead in an hour. They are used to some extent in naval battles and are very cheap in construction. In some mines of this type clockwork is used which after an hour throws the firing gear out of action while in another type delay-action devices for opening valves to admit water are employed so that the mine is sunk after a definite time interval.

To some extent chemical methods are employed to fire the charge in floating mines, but a disadvantage is that the explosion does not take place instantaneously as is the case with a mechanically fired mine. A glass tube is attached to the mine which is broken when struck by a ship; water enters and by coming in contact with sodium or potassium fires the charge. Other chemicals such as sulphuric acid have also been used to fire the charges in floating mines.

Loading an American mine. Unanchored automatic or floating mines must be dead in an hour. Various devices are incorporated to obtain this result

The Cost of the Great War

A chain of double eagles extending forty-four thousand miles is the cost of the war to date

$12,100.68—The Cost of Killing a Man in War

By Herbert Francis

WHEN walking along the Ringstrasse in Vienna one day a few years ago, I found myself in the neighborhood of the Hofburg, the Imperial and Royal palace. It was one of the days when visitors were admitted to the "Treasury of the Imperial House of Austria," so I turned through the gate and having witnessed the impressive ceremony of the changing of the guard, paid my krone and marched in. Purchasing an official catalogue of the treasures, I looked at the display of royal insignia, crowns and swords, the sacred relics such as a nail from the true cross and a tooth reputed once to have rested in the jaw of John the Baptist, and the diamonds, emeralds, pearls and rubies included in the list. Of all that I saw, I was most impressed with a sentence in the introduction to the aforementioned catalogue. It read that in 1876 it had been "decreed that in the future the Hapsburg - Lorraine private treasure should only include those objects which were held to be essential as demonstrating the power and wealth of the reigning family."

It costs over twelve thousand dollars to kill a man in this war

This might do very well for the consumption of the ignorant peasant of the Austro-Hungarian empire, but I imagined what would be said of the taste of a democratic American family which should thus blatantly announce in opening its gallery of art objects and relics to the public that the collection had been made with the purpose of "demonstrating the power and wealth of the family."

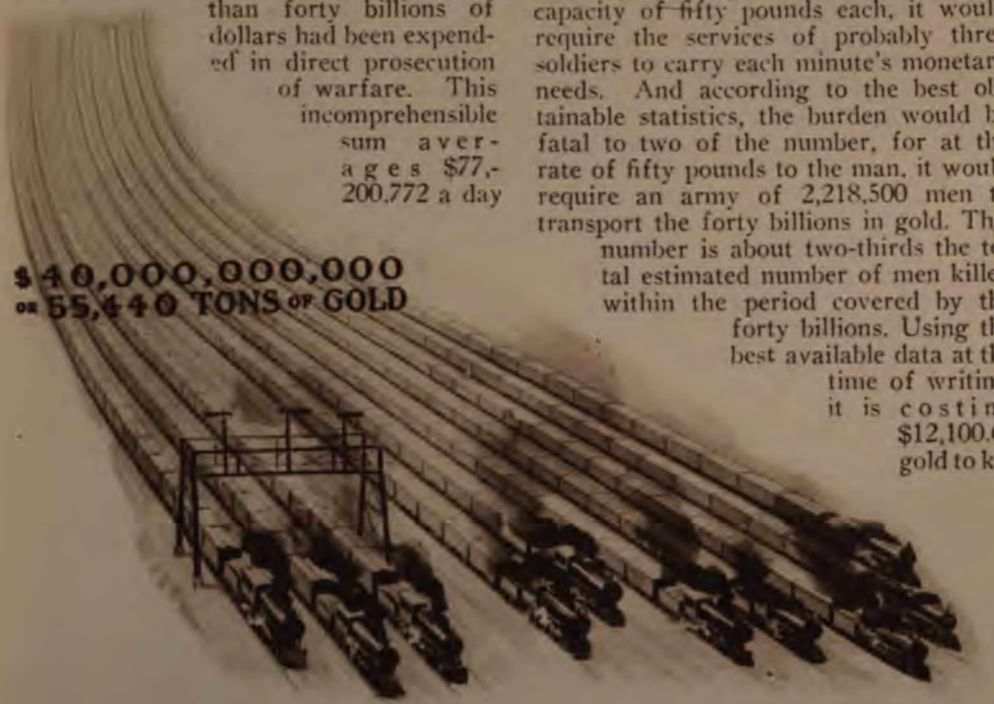
Later I visited the royal palace in Berlin. My chief recollections are of the plaster imitations of curtains with which a number of apartments were bedecked, the great felt slippers with which every visitor was equipped in order to protect the polished wood floors, and the theatrical manner in which the Kaiser's gold plate was displayed in the throne room. The golden vessels reposed on a metal framework so designed as to give opportunity for the close examination of each piece. The whole was enclosed in a glass cabinet with mirrors at the back. As the visitors entered the room an attendant would open a small door in the wainscoting and throw an electric switch, lighting up the interior of the glass case with invisible globes. By means of these footlights it was possible to see clearly both the front and the back of the golden dishes. With truly Teutonic efficiency, the at-

tendant cut off the current as soon as the visitors turned to leave the apartment.

I have described these two exhibitions by which the Teutonic rulers chose to demonstrate their wealth and power by way of showing how standards change. For more than a year now a method of demonstrating wealth and power has been exhibited in continental Europe which makes the old seem disgustingly cheap and picayune. All the jewels and gold plate in the palaces of Vienna and Berlin taken together would not foot the war bill for one day.

Three men would be required to carry the gold used to run the war for one minute

While exact figures showing the cost of the war will not be compiled until after it has come to a close, yet estimates have been made which show what a great destroyer of wealth it is. The best estimate is that up to January 1, not less than forty billions of dollars had been expended in direct prosecution of warfare. This incomprehensible sum averages $77,200,772 a day since war began and does not take into consideration the billions of dollars' worth of property wiped out in the countries invaded and through the deaths of millions of workers. For each minute of the day, the nations at war are obliged to pay out $53,611.64. Imagining this to be in gold and put into bags having a capacity of fifty pounds each, it would require the services of probably three soldiers to carry each minute's monetary needs. And according to the best obtainable statistics, the burden would be fatal to two of the number, for at the rate of fifty pounds to the man, it would require an army of 2,218,500 men to transport the forty billions in gold. This number is about two-thirds the total estimated number of men killed within the period covered by the forty billions. Using the best available data at the time of writing, it is costing $12,100.68 gold to kill



It would require fifteen trains of seventy cars each and one of fifty-seven cars to carry the gold spent in carrying on the war up to January 1, 1916

a man. War is a costly undertaking.

It was once even less efficient and more costly. In the Civil War, the number of Northern soldiers who died was 360,222, while the South lost, at the lowest estimate, 250,000. That war cost the North $6,189,929,908, while the South's bill was at least $3,000,000,000. It therefore cost approximately $15,059.97 to slaughter a man. Killing is done in a more wholesale fashion nowadays.

Fortunately, the warring nations are not obliged to gather together the forty billions and transport it at one time to the front. If they did, it would require fifteen trains of seventy cars each, and one of fifty-seven, each car being of the fifty-ton pattern used in hauling coal from the Pennsylvania mines to tidewater at New York harbor. This would interfere with the movement of food supplies, guns and other munitions of war for the time being. The weight of the gold would be 55,440 tons.

Even if it were desired to do this, there is not enough visible gold in the world to permit it. According to the figures of the director of the mint, the world's production of the precious metal between the years 1850 and 1913 inclusive, was $12,072,058,618, or less than one-third the estimated cost of the war. This, added to the $225,000,000 assumed to be in the hands of the potentates and other wealthy Europeans prior to the discovery of America, and the $3,383,224,000 figured to have been brought to view between the time Columbus first saw the Western Continent, and the discovery of gold in California, still leaves a deficit of nearly twenty-five billions to be made up otherwise.

But let us suppose there were forty billions of gold in the hands of mankind, and that through some gigantic financial operation it had reached America and been coined into double eagles. There would be, if the gold were alloyed with other metal to the usual degree of fineness, 2,222,222,220 of them, enough to cover the site of the Woolworth Building to a depth of seven feet eight inches, or form a pillar the height of the building, seven hundred and fifty feet, and twenty-two feet square. If placed on edge and face to face, they would form a roll 3,653.42 miles long. This roll would extend from New York to a point in the Pacific Ocean about six hundred miles west of San Francisco. Or, taking their diameter as one and five-sixteenths inches, they would pave a boulevard three hundred and fifty-one feet wide extending from one end to the island of Manhattan to the other a distance of thirteen miles. What a shining road that would be! The Irishman who expected to pick up dollars in the streets as soon as he landed, would literally be able to do it, assuming that the gold pieces were no better secured than is the surface of some of New York's thoroughfares. That great highway, broader than Broadway, would be the nearest approach to the streets of the New Jerusalem described by John, that the world could ever expect to see. And if all these gold pieces were laid flat in a single row, edge to edge, they would extend 43,841.12 miles around the waistcoat of the globe.

This would, indeed, be a "demonstration of power and wealth" that would make the display of jewels, relics and gold plate of the Teutonic ruling families look like a penny peep show.

A Mystifying Chemical Trick

A PLAIN blue handkerchief is shown to the audience. When the handkerchief is warmed it turns white and when heated resumes its former color.

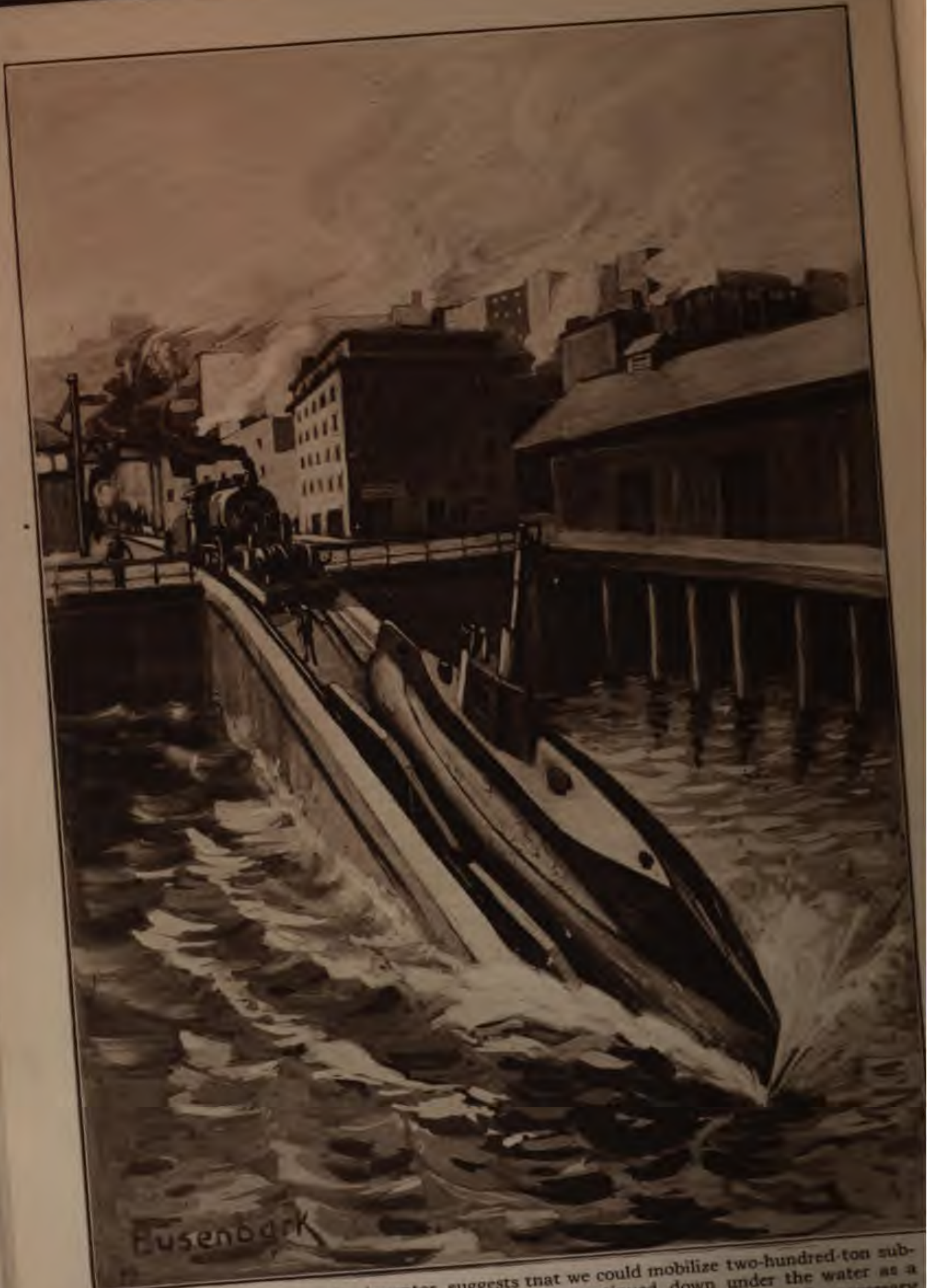
Make a starch paste and add enough water to the paste to thin it. Then add sufficient tincture of iodine to color the liquid blue; a few drops will be enough. Dye a white handkerchief with this blue liquid and when the handkerchief is dry it is ready for the trick.

Raising a Motorcycle Stand Automatically

A MOTORCYCLIST may save the time and trouble of raising the stand when the machine is pushed off, by fastening one end of a door-spring to the stand near the bottom, and the other end to a convenient place on the luggage carrier. While the machine is on the stand, the spring is stretched, but the removal of the weight releases it, and the stand is pulled back into place.

Salving Seven Thousand Dollars' Worth of Death

British Jackies hoisting a spent torpedo to the deck of a torpedo-boat destroyer. Torpedoes such as the one shown cost nearly seven thousand dollars, and, as may be imagined, is considered worth saving



Simon Lake, the submarine inventor, suggests that we could mobilize two-hundred-ton submarines by rail. "The railway tracks would be continued down under the water as a submarine railway at such points as the government might desire. It would be necessary only to back the truck and submarine down into the water until the submarine floated"

Undersea Fighting of the Future

I.—Mobilizing Submarines on Rails

By Simon Lake

Under the general title "Undersea Fighting of the Future," we publish two articles, by two distinguished engineers, in which the possibilities of the submarine are set forth in a way which shows that we have only begun to learn the use of the most powerful naval weapon thus far developed. Mr. Lake's article deals with the mobilization of submarines for defense; Mr. Chandler's with a highly ingenious method of engaging and destroying submarines under water.

Simon Lake came prominently before the public notice about fifteen years ago as the inventor of a submarine on wheels—a craft which could not only navigate under water but which could also travel on the bottom of a waterway. He acted as advisor on submarines to the German and Russian governments.—Editor.

Simon Lake the author of the article on this page, is the inventor of the "even-keel submergence type" of under-water craft which has in recent years been introduced by most of the navies of the world

I FIRMLY believe the destiny of the submarine is to stop all future maritime wars between countries. A tremendous power for destruction, the submarine is in itself useless for purposes of invasion. The moment the submarine becomes visible it becomes vulnerable. Its function, therefore, is to lie in wait and attack unawares. All students of warfare must now admit that it is manifestly impossible to send an army across the sea with big guns and troops and to land them, if submarines are on watch. I believe all engineering experts must also admit that when the proper motive power for submarines is evolved, a motive power which will give the submarine the speed of a surface ship, then merchantmen cannot carry on commerce on the high seas except by mutual agreement equitable to all nations. And I believe this will hasten the day when each country will consent to agreements to "do unto others as they would be done by."

If, in time of national differences, it were possible for each country to encircle itself with a zone ten miles in width, to pass which would be sure death, it would not be long before quarreling countries would make up their differences. If our country had sufficient submarines to protect its coast line and to establish such a similar zone, an offensive war would be rendered unnecessary.

Last year Congress made an appropriation calling for 25-knot submarines, to cost not more than $1,500,000 each. I saw this reported in the newspapers and I immediately wired the Department that it was impossible to secure 25-knot boats for less than about two-and-a-quarter million dollars each, and I later advised that it would then probably take several years to develop a suitable engine. The largest submarine engine of which I know is one of 1300 horsepower, completed in Italy for one of the large German boats just at the beginning of the war.

As it would probably require about 10,000 horsepower to attain twenty-five knots, Congress hardly realized how stupendous was the problem of producing at a single step a boat capable of traveling nearly twice as fast as the best underwater vessel of the day. No wonder there were no bidders for a 25-knot boat.

While it was impossible, even with unlimited money, in the present condition of internal combustion engineering, to develop a 25-knot submarine boat quickly, it is possible to get quickly a large number of 50-knot submarine boats of small size, which for the same expenditure would prove many times more effective in warding off an attack than the larger boats. I refer to what I call "amphibious submarines;" that is, submarines of about two hundred tons displacement, which could be hauled on special railway trucks from one point of the country to another at a speed of fifty knots per hour, with crews, stores, equipment, all on board. The railway tracks would be continued down under the water as a submarine railway at such points as the Government might desire. It would be necessary only to back the truck and submarine down into the water until the submarine floated. Her commander would only need to give the bell and she would be off. Such boats could probably be built for three hundred thousand dollars each to make ten knots on the surface and about eight submerged. It would be possible to get six or eight such boats for the cost of one twenty-five-knot bo[illegible] [illegible]d cover six to eight times as [illegible] [illegible]itory. A torpedo fired from a [illegible] inexpensive boat is just as effective as one fired from a large, expensive boat. The small boats could make the trip from New York to San Francisco in four days, New York to Boston in five hours, New York to New Orleans in thirty-six hours, in perfect safety, while a modern large submarine, under war conditions, could probably not make the trip at all, except as a slow-going surface boat, liable to capture or destruction. One hundred of these amphibious submarines could be quickly turned out by the various shipyards throughout the country, and it would also be possible to get engines quickly for them: the power required permits of using sizes of engines that have already been developed by several concerns. Such a system of coast protection would enable the quick mobilization of a large number of submarines at any threatened locality, for harbor or coast defense purposes. Of course it would be advisable to have a large number of submarines for off-shore work or to patrol the coast where distances between ports or harbors would be too great for the smaller craft.

Many disadvantages accompany the use of the storage battery. It is very heavy for the horsepower energy it carries. It is also bulky, so that only sufficient energy may be carried to propel modern submarines at about eleven knots per hour for one hour, about eight knots per hour for three hours, or at about five knots per hour for twenty hours. This means that when the energy is exhausted the submarine must ascend to the surface or secure surface connection in order to obtain air to enable her engine to be run to recharge her batteries. This is likely to prove her undoing, as the noise of her internal cumbustion engines in charging, can, with a proper receiver, be heard many miles, and would direct an enemy surface boat or submarine to her. Therefore, before the submarine can become invulnerable, she must become capable of operating without sound. If it were possible to produce some sort of primary battery whereby energy-producing material could be put into the battery like [illegible]al into a furnace, it would be ideal for [illegible] [illegible]do-boat use, and the [illegible]n become invincible.

Undersea Fighting of the Future

II.—Battling with Telephones

By Edward F. Chandler

The author of this article has conducted extensive researches in the art of submarine radio transmission, applying the results to defensive and offensive means of warfare. The system of submarine navigation described in this article is the result of conclusive tests.—EDITOR.

IF the war has taught us anything it has taught us that the submarine must be reckoned with both as an annihilator of battleships and as a destroyer of commerce. Of the dozens of instrumentalities invented for killing on a wholesale scale it is the most terrible. And yet how crude is this new weapon! Compared with what it can be made it is what the blunderbuss of old is to the modern rifle.

Consider for a moment how a submarine boat is handled. The commander plows along at the surface much as he would on any ship. In the offing he sees a pillar of smoke. Friend or foe? He must investigate. Changing his course, he steers for that cloud on the horizon. In fifteen minutes he has approached near enough to discover that the smoke is pouring from the funnels of a hostile collier. She flies the naval ensign of her country, and she is convoyed by a torpedo-boat destroyer. The submarine commander gives an order. Water surges into tanks in the submarine's hold. The craft sinks until only her periscope projects from the water. Heading for the collier the submarine arrives within half a mile of its prey. The commander takes the bearings of the collier by compass and orders complete submergence. In another minute the craft is completely under the surface. A sharp command, and a puff of compressed air starts a torpedo from one of the launching-tubes. In less than a minute it has reached the collier. There is a dull explosion. Fifteen minutes later a cargo of four thousand tons of coal lies at the bottom of the sea, and a hundred brave men have perished miserably.

Edward F. Chandler, whose most important work thus far probably is the development of a submarine range-finding system and its application to the detection and destruction of hostile submarines

Why the Submarine Is Crude

It seems very simple, very certain, this torpedoing of a ship from a safe place under the water. But for all that it is unscientific and haphazard. The submarine commander sees nothing below the surface; that is why he must take aim before he submerges. To strike, the target must be large and very near; otherwise he would surely miss. Suppose that you were told to shoot blindfolded at a mark one hundred yards away and that you were given two minutes to locate the target before your eyes were covered. You would be exactly in the position of a submarine commander about to torpedo a hostile ship. Is it any wonder that torpedoes must be fired at close range? Is it not obvious that the submarine could be made still more terrible if the submarine commander could locate his quarry accurately in the inky blackness in which he is immersed?

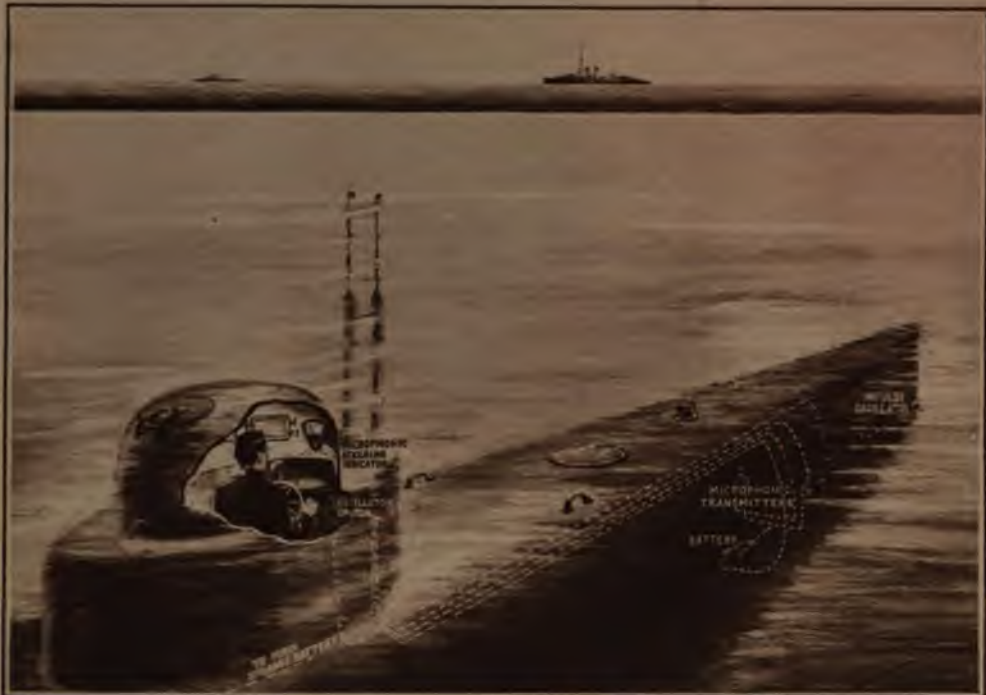
To use lights under water is hopeless. Even millions of candlepower would not reveal the presence of a ship a mile off to a submerged underwater craft. But suppose that the commander of a sub-

Although the submarine is blind after it dives it can be made to hear with the aid of microphones. If two hostile submarines were equipped so that they could hear each other there is no reason why they should not fight under water. Torpedoes would be the weapons used—torpedoes directed solely by the sound emanating from the craft to be destroyed

marine could locate his prey by sound; suppose that he could hear a ship and locate her by sound more accurately, for example, than a blind man can locate the position of a ticking clock in a room? Might not that solve the problem?

With this thought in mind, I have worked out a method of utilizing microphones. A microphone is found in every telephone transmitter. It is an instrument for intensifying feeble sounds, or for transmitting sounds, and it is based on the principle that the transition between loosely joined electric conductors decreases in proportion as they are pressed together. The conductors form part of a circuit through which a current is passing, and the variations in pressure due to sound waves in the vicinity of the conductors produce variations of resistance, and hence fluctuations of the current, so that the sounds are reproduced in a telephone receiver. In the modern telephone the transmitter is essentially a microphone, the pressure of the sound waves being communicated to the conductors by means of a diaphragm.

In a torpedo the microphones would be mounted in pairs on both sides of the nose. So long as the sound of the hostile ship's beating propellers, traveling through water far more readily than sounds travel through air, affect all microphones with equal intensity, the torpedo rushes on straight to its mark. But if the vessel should change its course, the vibrations of the propellers would no longer strike the two pairs of microphones with equal force; one pair would be more affected than the other—the pair directly ex-



In order that a submerged submarine may direct its course accurately toward a hostile ship it may be provided with microphones on its port and starboard bows. The difference in the volume of sound received by the two microphones indicates the course to be pursued. The sound can be converted into movements of a finger playing over a dial

posed to the vibrations. At once electrical circuits are closed and automatic mechanism started which swings the rudders of the torpedo and points the nose of the torpedo toward its mark. As soon as the microphones on both sides are restored to electrical equilibrium, in other words as soon as they hear with equal clearness, the torpedo keeps on a straightaway course.

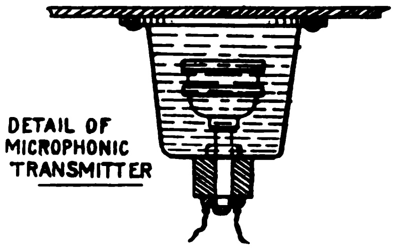
It is evident that the same principle can be applied to submarine boats traveling under water, with the difference that since the submarine is manned by intelligent human beings, the microphones can be made merely to indicate the course to be pursued, leaving to the commander the task of steering a true course. As in the case of the sound-controlled torpedo, the submarine is provided with microphones on its port and starboard bows. Telephone ear-pieces are provided which enable the submarine commander to listen to the sounds gathered by the microphones. If the submarine is not pointed head on toward the ship to be destroyed the microphone on the off side will hear less than the other, and the difference in the volume of sound received by the two microphone detectors will be noted at once in the telephone receivers. The commander changes his course until he hears equally well with both ear-pieces.

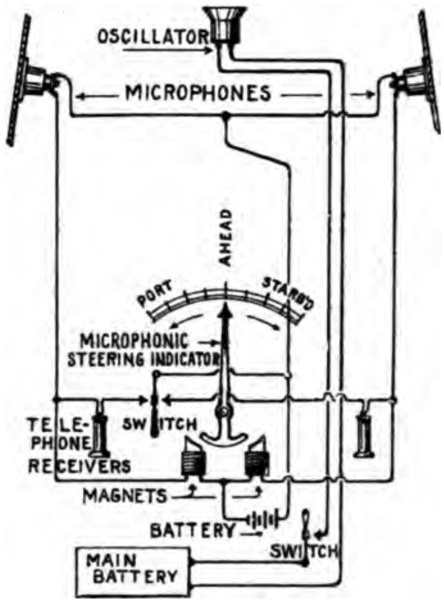
Seeing Sounds on a Dial

While it is perfectly feasible to direct a submarine by telephone it is much more effective to convert the microphone vibrations into visual signals. As a result the commander of a submarine has only to watch a finger move over a dial in order to know what course he should steer. In a sense he sees the sound which the microphone detectors hear. The accompanying diagram sets forth the essential principles of this conversion of the microphone vibrations into visual signals so clearly that an extended description seems hardly necessary.

While a visual steering indicator is

primarily depended upon to guide the submarine on its deadly errand, telephones are connected with the microphones, to be used when the occasion arises. With their aid the commander learns a new language. He realizes the meaning of strange grindings, hums, moans, blows, murmurs and vibrations —the many tongues of the sea. If we but knew it the water of the ocean is a veritable Babel; it is a great reservoir of sound, the recipient of ten thousand different vibrations, ranging from the grinding of pebbles to the pounding of steamship engines. Just as a woodsman learns the meaning of the weird soughing of wind in tree tops, the "woof" of a bear, the patter of deer's feet and the call of quail, so a submarine commander can distinguish one underwater sound from another and interpret it correctly. A tramp steamer can be microphonically distinguished from a *Mauretania*, a torpedo-boat from a superdreadnought, and above all a subsurface craft from a surface craft. Thus the character of an unseen ship miles away can be ascertained.





A diagram showing the Chandler system of converting sounds heard through a microphone into visible signals

But apart from listening to passing ships, the telephones will be required to receive messages from an admiral on a battleship five miles away. Both warships and merchantmen are equipped with submarine signaling devices—devices which send forth either bell sounds or rhythmic vibrations. It is easy to see how useful they can be made to telegraph orders to a submarine under water five miles or more away.

Under Water Echoes and How They Are Applied

In the foregoing account of my invention I have assumed that the vessel to be attacked with the aid of the microphonic steering-indicator is in motion—that its engines are giving audible sounds and that its propellers are churning up water noisily. But suppose the vessel to be attacked is at anchor—what then? Is not the submarine commander helpless?

The difficulty is easily overcome if we can make the submarine produce a characteristic sound and if we can have that sound echoed back from the ship to be sunk and picked up by the submarine's own microphones. Fortunately Professor Fessenden has provided an instrument ideally suited for the purpose. Called an oscillator, it may be regarded as a kind of underwater klaxon norn, the diaphragm of which is electrically vibrated to emit a characteristic bleat. By means of a switch, located near the hand of the submarine commander, the oscillator can be turned on or off.

The oscillator will be of use not only to locate a ship at rest but to save the submarine in a nerve-racking emergency. Imagine the commander of a U-boat bent on the destruction of a ship entering a harbor and traveling along at the surface with only his periscope exposed. A fast armed motorboat looms up—a type of craft which has proved to be a most formidable enemy. The submarine must act quickly. There is but one course—to sink quickly. Valves are opened and tanks filled. The craft

sinks out of sight. It is safe for the moment. The agonizing uncertainty of the crew can be imagined. They know that a relentless enemy awaits them, that his searchlights sweep the water all night. Hour after hour drifts by. If the submarine's commander rises, a hail of shot and shell is sure to rain upon him; if he stays under water very long he and his men will die of suffocation. Why not move on? The waiting motor-boat cannot see him. But in what direction and how far? He is almost sure to run into the shore and to puncture the thin shell that saves him from inundation. If he could only locate the harbor entrance he would be safe. An oscillator and a set of microphones will enable him to head for the inlet as surely as if he were traveling on the surface and he could see it with his eyes. He pulls the switch of the oscillator. A shrill note is sent through the water. His eyes on the steering indicator dial, he watches the response of the finger to an echo. The echo of what? Of the oscillator's vibrations reflected by the shore. He steers this way, now that way, barely crawling along, always watching for the echo on the dial. The finger on the steering indicator moves from side to side as the microphones pick up the echoes. At last there comes a moment when the finger stays at zero, when, in other words, there is no echo for the microphones to hear. That can mean only one thing: the oscillator is sending out its bleat not toward an echoing shore, but toward the harbor's mouth and toward the open sea, where safety lies. With his eye on the steering indicator the commander signals "full speed ahead," knowing that salvation lies before him.

Artificial Senses Take the Place of Eyes and Ears

The use of microphones on submarines not only increases the effectiveness of the submarine enormously, but opens up new and intensely dramatic possibilities. As soon as one submarine is equipped with devices for threading a course underwater with certainty all submarines will be similarly equipped. Grant that and at once we have the means of pitting submarine against submarine, of actually engaging in submarine fights. What strange encounters they will be—these underwater engagements of the future! Two vessels, blind but for steering indicators connected with microphones, circling around each other in the effort to ram or to plant a torpedo at the right moment, cocking electrical ears, as it were, and maneuvering entirely by sound—what battle of Wells or of Verne's can compare with it? Instruments, artificial senses, take the place of Nature's eyes and ears; hidden movements are electrically translated into twitches of a quivering finger on a graduated dial; one intelligence is pitted against another. Surely this is real scientific warfare—this battle of microphones!

A Sewer Banquet at $25 a Plate

TO celebrate the completion of a new sewer in St. Louis a cabaret banquet was held in the tube. A "banquet room" three hundred feet long and a gas-equipped kitchen were created. The food was cooked in the tunnel and served on twelve tables placed lengthwise.

The cost of the banquet was twenty-five dollars a plate.

The underground kitchen in which the meal for a banquet given in St. Louis' new sewer was cooked

The Artifices of Modern Warfare

A submarine commander has but one means of judging the speed of the vessel to be attacked —by noting the size of the bow-wave thrown up by the intended victim. The correctness of the estimate means either a hit or a miss. The British have devised a clever method of confusing the German submarines. A huge bow-wave is painted on the sides of the ship, rendering it extremely difficult for the underwater craft to judge the speed accurately. In the insert is shown a heavy Austrian Skeda howitzer concealed with hay to make it invisible to the Russian air scouts

Watching a Battle Through a Super-Periscope

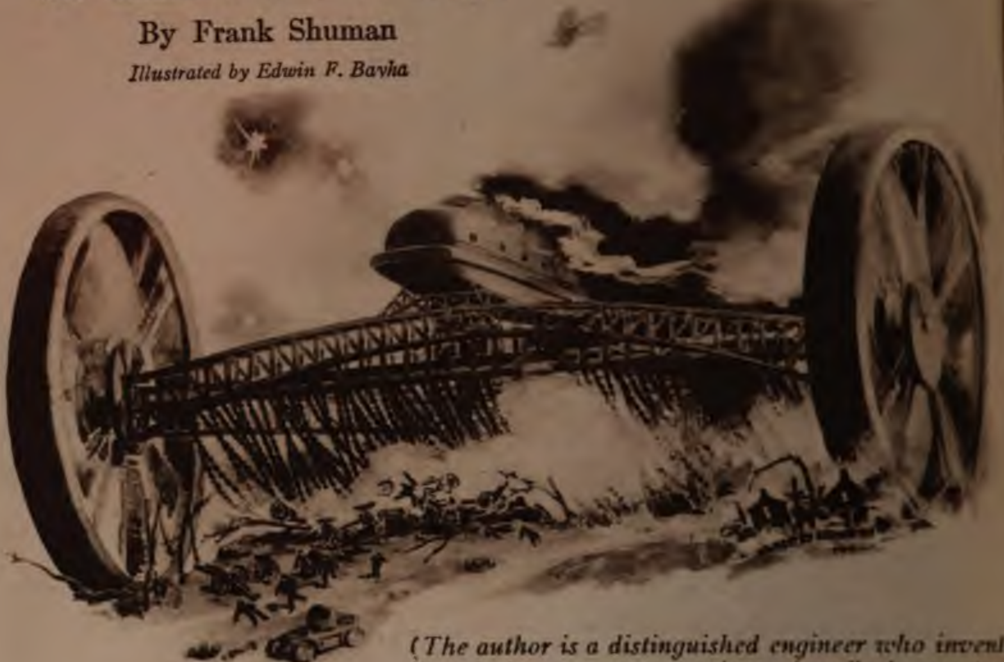
Secreted in their headquarters in the wine cellar of a demolished chateau, the officers are able to watch the battle raging outside with the aid of an immense periscope supported in its place by a wall of masonry. The roof of the cellar is covered with bomb-proof pads. There is nothing to betray its location to the enemy—not even the glinting of the sun on the exposed glass surface, as is so often the case where telescopes are used. The big periscope affords a wide view of the field, while at the same time the observers are safely sheltered

The Giant Destroyer of the Future

Can a juggernaut be built which will annihilate a whole army?

By Frank Shuman

Illustrated by Edwin F. Bayha



(The author is a distinguished engineer who invented the daring sun-power plant described on pages 318-321. His concrete piles, wired glass, wool-degreasing machines and other inventions have made him famous.—EDITOR.)

A CLUB, a bow and arrow, a blunderbuss, an infantryman's rifle, a forty-two centimeter howitzer are merely instruments for delivering blows. The essential difference between the battles of prehistoric times and those of today lies in the manner of delivering blows. Smokeless powder has merely lengthened the arm of a modern fighter. He strikes and kills at a distance of miles.

For all our machine-guns, for all our terrible "artillery preparation," battles are still won by bayonets. Tactics have been somewhat modified since Napoleon's day, because of the invention of the machine-gun and the high-powered field-piece. But the individual fighter is still as important as he ever was. We speak of the German or French or Russian "war machine," when we mean a million or more individuals trained to act with a precision that roughly approximates that of a modern university football team.

Only the Battleship Is a Real War Machine

Because armies are still composed essentially of many individuals, fighting ships may be more fittingly termed "war machines." A modern battleship is a real machine. The men on board are merely so many intelligences that control the steam-engines, the turrets, the great guns, the searchlights. No one ever hears now of hand to hand conflicts at sea. Ships are sunk at ranges of five and seven miles. But land warfare is still waged not by a few machines, as on the sea, but by organized millions of men.

Armies have increased in size. Fighting ships, on the other hand, have diminished in number. Contrast the numerical strength of the British Navy now with what it was in the days of Drake and Nelson. A few dozen ships, highly intricate machines, have taken the place of hundreds.

Why is there no land battleship, something comparable with our own *Penn-*

something which will concen-
ithin one volume the striking
f an army?

Not a Battleship On Land?

is no good engineering reason why
mous wheeled structure, heavily
and capable of traveling at high
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land much as an automobile travels over a country road. A hill fifty feet high would be to that machine what a six-inch ridge of clay would be to an automobile; a swamp would no more hinder its course than half a foot of mud would stop a touring car. Its speed would be at least one hundred miles an hour on the long, level, sandy beaches along our coasts. And even over rough inland country it would rush far more swiftly than any touring car on a poor road. Indeed, in its speed would lie its destructive possibilities. The impact of a heavy mass moving with the velocity of an express train would be irresistible. It could mow down everything before it with the relent-

nachine proposed by Mr. Shuman would be irresistible. With its front wheels measuring
eet in diameter, and the weights aggregating many tons dangling down in front from chains,

lessness of a steam-roller. Guns would not be required to rout an enemy. An army would be as helpless in offering resistance as a flock of geese in the path of an automobile.

A Giant Three-Wheeled Armored Car

It is impossible within the limits of a short article to describe this machine which I have conceived in all its details. Picture to yourself, however, a self-propelled machine, comprising three wheels and a heavily armored body or car. There are two wheels, one hundred and fifty to two hundred feet in diameter in front, and a single smaller steering-wheel in the rear. The entire structure is short, so that the turning radius will be small.

No doubt you are familiar with the military masts of our American battleships. They are latticed towers, not unlike cages. They are thus constructed so that whole sections of the lattice work may be shot away; but the remaining portions will still support the mast.

So I would build the wheels of my war machine. Why not armor them instead? They would weigh far too much—thousands of tons in fact. But the hub I would armor—and heavily. There the spokes would be concentrated so thickly that they might be shot away in great numbers. Besides, the hub and axle must be well protected. Therefore the center of each wheel would be a mass of armor as thick as that of a battle cruiser.

The two front wheels of this war machine

it would plow through a whole town, blotting it out of existence as if it were a mere ant-heap. The wheels would be latticed, so that shot might pass through without destroying them

Ordinary rivers and marshes would not stop the machine. Few rivers are more than fifty feet deep. The 200-foot wheels of the machine would dash through them as easily as an automobile through a pool of mud

would have to be spaced about three hundred feet apart. They would have a tread about twenty feet wide,—in other words, about as wide as an ordinary room. I would make them of steel plates four inches thick, bolted together in sections.

Since the machine is to destroy by virtue of its inherent energy and not by means of guns, it would have a comparatively small car—a car which would not rise above the tops of the front wheels, which would be heavily armored, and which would serve primarily as a housing for the engines. The crew would be small—not more than perhaps thirty men.

I am fully aware that the problem of obtaining engines which will give this war machine a speed of one hundred miles an hour is not easily solved. But if thousands of horsepower can be developed by the engines of pitching and rolling battleships it is not unreasonable to suppose that competent engineers can be found to design and build steam engines of twenty thousand horsepower, fed by oil-fired boilers.

Once more let me state that the front wheels are one hundred and fifty to two hundred feet in diameter. Hence, they would make less than fifteen turns to the mile.

How Shocks Would Be Absorbed

That simplifies the matter of absorbing shocks. If a racing automobile on a fine track leaps into the air when it strikes even a pebble, simply because the spring suspension has not time to respond to the shock, it is obvious that the huge structure that I have in mind must be provided with inordinately strong yet sufficiently sensitive shock-absorbers. The shock that would be experienced in knocking down a small factory building, would certainly not be as great as the shock that must be absorbed as a modern fifteen-inch naval gun suddenly recoils after discharge. If cylinders filled with oil can check the terrific recoil of a big gun, they can also act as shock-absorbers on a land war machine. And so they can be imagined on the machine—huge cylinders, three feet in diameter, filled with oil which would resist the pressure of pistons on the axle.

The weight of the entire structure would be probably five thousand tons. Since the machine is to batter down everything in its path, there are to be suspended from the front of the machine a series of heavy weights, each weighing several tons. The weights may be raised or lowered. When dropped into position their impact at high speed would level everything before them.

Only Big Guns Could Stop the Machine

Terrible as this contrivance would be, it would not be able to withstand bombardment by 16-inch Skoda or Krupp guns. It is not intended for that. Ordinary field artillery will not stop it. Its sole purpose is to move up and down an enemy's country, to make a whole region untenable, to crush down resistance offered by ordinary field fortifications. Mines will be planted to blow up the destroyer. Mines do not prevent a battleship from venturing upon the sea. Moreover, the maneuvering power of the land war machine will be such that it may change its course wilfully with such rapidity that a whole countryside would have to be blown up in order to affect it.

Imagine yourself standing at one front wheel of this machine. Comparatively you would be no bigger than a baby standing beside the driving wheel of a passenger locomotive. Far above you would be the maze of spokes constituting the latticed wheel. Perched midway between the two gigantic front wheels, as tall as many a moderate sized office building, would be the ship-shaped armored car for the engines and the crew. You reach it by means of an elevator resembling that in which miners rise from deep coal mines. Once in the car, you might fancy yourself in the engine room of a ship; there is no difference so far as general appearances go. With the commander you step into the conning-tower—a circular, armored chamber well forward, dominating the entire landscape.

The commander gives a signal. The machine moves. It gains headway. Soon it travels at express-train speed. A mile ahead is a densely wooded park. In a minute the machine reaches it. Does it stop or swerve? It plunges on. Trees are crunched as if they are mere weeds. You look back in the wake of the machine. It is as if a storm had laid low every poplar and elm. And yet the machine is not even scratched. An enemy village, occupied by enemy soldiers lies in front. The machine speeds on toward it. It reaches them. Houses are battered down as if they were made of paper. Wherever the weights that dangle down in front strike, wherever the wheels move, there is a rending and a crushing. And so, everything is leveled before the war machine—walls of earth or masonry, houses big and little, railway stations and signal bridges.

To throw the projectile pictured, 666.5 lbs. of smokeless powder are used, and to cause the huge mass of metal to scatter into countless death-dealing fragments, 96.04 lbs. of powder are packed in the shell. The total weight of the shell is 2,900 lbs., enough to pierce the heaviest armor of the most powerful battleship afloat. The blunt cap on the end of the projectile is made of soft steel, and holds the cap together when the shell hits its target. It acts much the same as the cork used in the familiar parlor trick of driving a needle through a coin. The cork prevents the needle from breaking while it is piercing the metal, and the blunt cap of the shell keeps the point intact while the projectile drills through the armor. Underneath the soft steel cap is the usual time or percussion fuse, which, without the protection, might easily become injured by the impact of the great projectile against a heavily armored fort or battleship

Courtesy Smithsonian Institution

Our 12-inch armor-piercing shells explode after passing intact through the armor plate of the target and are broken into many fragments

A SINGLE MEAL FOR ONE OF OUR BIG GUNS

Enlisted Men: The Foundation of the American Navy

By Josephus Daniels, Secretary of the Navy

Josephus Daniels

Loading a four-inch gun in battle practice on the cleared deck of a torpedo boat

ONE of the curious and unexpected things which I have found since I assumed the duties of Secretary of the Navy has been the effect of a too near point of view in destroying the perspective of some of our ablest Naval Officers as to what the subordination of everything connected with the Navy to its military functions really means, and how far back military preparation must begin.

As each new civilian Secretary of the Navy assumes office, it has of ancient custom been regarded by the service as necessary for the Naval officers with whom he comes in immediate contact in the Department to impress upon him that the Navy is a fighting machine, that its sole purpose and reason for existence is to fight and fight effectively, and that everything that is done must be done with this foundation principle constantly in mind. This is an almost self-evident truth, and it would be indeed a dull mind that could not grasp it and agree, but in the carrying out of this principle there is, I find, a tendency to begin at the top, and, working down towards the foundation of things, to stop suddenly before the bottom is

reached. Thus, in all matters of discipline aboard ship.

Thus, in matters of discipline aboard ship, in the training of crews and squadrons, in maneuvers and strategy, in armament and equipment, the idea of military efficiency has been splendidly carried out, and in these matters I hold our Navy ranks second to none.

Have Our Officers Lost Perspective?

When it comes, however, to the utilization of our yards so that they will be of the greatest aid to the Navy as a military weapon, to the subordination of all our so-called civilian activities in the Department to the great military plan, and to the recruiting of men who will prove the most efficient military units, worthy of promotion, when fit, even to flag rank, many of our high navy officers have lost their perspective. This is all the more curious because the German military organization is continually held up by these naval officers as the ideal to be achieved, and if there is any one feature where the German differs from other organizations it is in the thoroughness with which the beginnings of things and things ordinarily thought of as particularly civil are bent and subordinated from the start to their place in the final military organization.

The need of perfectly trained crews so high in character and intelligence that they can grasp the most intricate matters of machinery and drill, that they can save tenths of seconds in the firing of a gun or keep in constant repair the most delicate electrical machinery, is recognized by navy officers as highly important, but there were many, until very recently, who considered that no special effort was required to attract to the service the class of men from whom these results can be obtained. Possibly this was because, in Germany, for instance, military service is compulsory, and the men with the brains and intelligence needed are compelled to enter some military arm of the service in any event, whereas in this country, depending as we do upon voluntary enlistments, high class men cannot be secured unless there are real inducements far more attractive than pretty pictures on recruiting billboards.

It was to remedy this failure to begin at the bottom in one of the most important military matters which led me to inaugurate new ways to attract the right class of men to the service and to keep them in the service when once so attracted by making the term of enlistment a great opportunity to obtain, at Government expense, an education, particularly along technical lines, which would enable the man, upon his discharge, to obtain a higher wage.

Opportunities for such improvement existed before I became Secretary, and, while they have been considerably enlarged since then, the only sweeping change has been to give to those enlisted men who lacked it the rudimentary school education needed before they could comprehend the mechanical and electrical trades.

What I have done, however, is to bring prominently before the country on every occasion the fact that such opportunities existed, and I believe there is hardly a young man anxious to improve himself who does not know that in the Navy he can find his opportunity.

Our Recruits the Cream of Youth

The result of this campaign has been gratifying in the extreme, and the Navy is now recruited to its full strength from so many applicants that we are able to pick the very cream, our latest figures showing that only *seventeen* per cent of those who apply are now accepted. In addition, while the value of a man who has already had the training of one enlistment term in the Navy is recognized as being far greater than that of a landsman just taken on board, and while the military importance of having men of long experience on every ship has been acknowledged, the equal importance of making the service attractive to the enlisted men in order to keep them in the service has not been sufficiently considered until recently. Without abating one jot of the rigid military discipline, without pampering or favoring the enlisted man at the risk of destroying his efficiency as a cog in a great machine, the number of re-enlistments has increased, as the result, from fifty-four per cent to

turing establishments as worth time and money in increased efficiency of workmen.

The young man who has mastered the fundamentals of some particular trade can enlist in the Navy and be assigned immediately to work at that trade with sure promotion ahead of him. The experience that he gets in the Navy will be far broader and greater in

The daily drill on the ship's deck is an important and interesting feature of the day's routine. Above, sailors in a battleship reading-room

The navy turns out good stenographers and typewriters as well as good mechanics

ninety-two per cent.

I am asking Congress this year for eleven thousand five hundred more men for our Navy. Thanks to the policy outlined, there is not the slightest doubt that we will be able to get eleven thousand five hundred (or more when they are needed) young men of the highest type, keen, intelligent, desirous of improving, and willing to learn their duties. It has simply been a case of willingness to learn from civil life the most efficient way to achieve a military object, for the education of apprentices has been recognized by great manufac-

all probability than he would get working at his trade outside. Take the young man who has gone in for electricity and who lives in a small town. He has few chances of learning the higher branches of his profession; wiring for electric

bells, occasionally repairing a small motor, putting in electric light fixtures—these are practically the limits of his experience. On every battleship, however, are to be found the most delicate and complicated of electrical apparatus, huge dynamos of enormous horsepower, delicate signaling and recording instruments; every kind of electrical apparatus is there. How to make and how to repair this apparatus is a part of his military education, progressing from the simpler work to that requiring the greatest skill, and with this training will go a thorough education in the fundamental principles of electricity as well.

Every Recruit is Trained to Become a Skilled Artisan

When he leaves the service he will be too proficient as an electrical expert to be in any danger of being compelled to spend the rest of his days as he began—putting up bell wires or installing electric lights in a small town. He will be a welcome addition to any of the great electrical and manufacturing establishments, with good wages, and perhaps a place at the very top.

This is true of all the other vocations, and fifty of them are taught in the Navy. There has just been established, for instance, a new class at Charleston for instruction in gasoline engines, where the enlisted men will be taught not only the theory but the practical handling of the largest gasoline engines now in use. Machinery of all kinds is used in these schools for enlisted men, and, in addition, what is known as the yeoman branch affords an opportunity for those who desire to become expert stenographers, typewriters and accountants. Here is a partial list of the schools for enlisted men at present maintained by the Navy. It is interesting as showing the wide range of subjects covered.

1. Navy aviation school.
   Pensacola, Fla.
2. Electrical schools.
   Navy Yard, New York;
   Navy Yard, Mare Island.
3. Artificers' school
   Navy Yard, Norfolk.
4. Oil burning school.
   Navy Yard, Philadelphia.
5. Machinist's mates' school and school for gas engines.
   Charleston, S. C.
6. Seaman gunner school and school for diving.
   Naval Torpedo Station, Newport, R. I.
7. Yeoman schools.
   Newport, R. I.,
   San Francisco, Cal.
8. Musicians' school.
   San Francisco, Cal.
   Norfolk, Va.
9. Hospital training schools,
   Newport, R. I.,
   San Francisco, Cal.
10. Commissary school (for ship's cooks, bakers and commissary stewards),
    San Francisco, Cal.,
    Newport, R. I.
11. Mess attendants' school.
    Norfolk, Va.
12. Naval Training Stations for apprentice seamen,
    Newport, R. I.
    Norfolk, Va.
    Great Lakes, Ill.
    San Francisco, Cal.

How thorough the instruction is, can best be shown by the course of instruction in the Navy Electrical School at the New York Navy Yard, which follows.

During the first week of instruction, the recruit studies machine shop work, such as forging, welding, tempering, annealing, brazing and soldering, and thread cutting.

In the second week, his machine shop instruction continues, the novice becoming familiar with the hand operated tools such as the lathe and lathe tools, the shaper and shaper tools, the drill press, the milling machine and mill-cutters, and the emery wheel. He also learns the rudiments of machine shop work, such as bench, lathe, drill press, milling machine and emery wheel work.

For the third week, he studies reciprocating steam engines, the various courses being in simple and compound reciprocating engines, also in the auxiliaries, viz., separators, traps, pressure regulators, all kinds of valves, condensers, pumps, gages, revolution counters, tachometers and indicators. Practical operation of engines and practical work also occupy much of his time. He learns assembling and dissembling engines, lining up engines, resetting and adjusting valves, reading indicators, overhauling and repairing engine and pumps and the regrinding of valves.

The subject of steam turbines is taught during the fourth week. The

practical operation and care and preservation of these complicated engines keeps the recruit busy during the week.

For the fifth week, the subject is that of internal combustion engines. The study of the principles of these engines, and of special types such as the Hornsby-Akroyd, Meitz and Weiss oil engines, is

Bluejackets in artillery and infantry exercises ashore. Above, a schoolroom on shipboard

The navy offers an opportunity to study electrical engineering

thoroughly pursued, and the practical operation, care and preservation of all oil engines is taught.

In the sixth week, the theory of magnetism and electricity is studied, and in the seventh week, the instructors teach the students the theory of the dynamo and electro-magnetism.

Practical work on dynamos is accomplished during the next two weeks, and pupils learn the mysteries of turbo-generators, switchboards, operating dynamos in parallel, care of the plant and dynamo room routine.

Theoretical and practical work on motors occupy the recruits' time from the tenth to the twelfth week. Studies are made of the principles of direct current motors, motor generators and dynamos, and practical work is done on service motors and motor starting and controlling devices. Ammunition conveyors and hoists, gun elevating

equipments, rammers and turret turning equipments are made the subject of study.

The thirteenth, fourteenth and fifteenth weeks are devoted to the study of the theory and practice of lighting and interior communication. The subjects listed are instruments, circuits and fuses, incandescent and arc lights, telephones, wires and wiring, wiring appliances and fixtures, search lights, signaling apparatus, interior communication cables, switchboards, telephone circuits, telephones and fire controls.

During the sixteenth and seventeenth weeks the theory and practice of primary and secondary batteries are studied.

The last two weeks, the eighteenth and nineteenth, are spent in a general review of the entire course, and any points that have been missed by the pupils are made clear in their minds.

Radio Telegraphy

For the first six weeks of the course in radio or wireless telegraphy, the study closely parallels the study of magnetism and electricity, dynamos and motors, alternating currents, batteries, and internal combustions which is pursued in the course just outlined.

From the seventh to the nineteenth weeks, the pupil is constantly practicing at the instrument, becoming efficient at sending and receiving. He also devotes one week each to the following subjects: Condensers, inductances, oscillating currents, primary circuits (transmitting), secondary circuits and closed oscillating circuits, radiating circuits, transmitting sets, receiving apparatus, receiving circuits, Fessenden sets, wireless specialty companies' sets, and Telefunken sets. The nineteenth week is spent in review, as in the other course.

Immediate entrance to these schools is, of course, obtained only by those who already have some knowledge of the trade, but every enlisted man who wants to take up a trade of which he may be utterly ignorant at the time of his enlistment has only himself to blame if he does not eventually acquire a chance to obtain this special shore instruction. He has only to state to his superiors on the ship what line he would like to follow and provided there are not too many already having the same desire at the time on the ship, he will be assigned duties on shipboard which will give him a certain familiarity with the subject. After a year's service, he can make application for a special course of training at the school, and, if he has shown sufficient intelligence and progress in his work on board ship, he is certain to have his request granted.

With such inducements and with a daily school on shipboard where the subjects to be found in every public school on shore are taught him as well, it is not surprising that, instead of a lack of men of the type desired, the Navy now finds it a difficult matter to choose from the host of applicants those best suited for the service. Judges no longer sentence ne'er-do-wells to the Navy as a punishment, nor are such men received, and desertions in the last three years have decreased thirty-two per cent.

In this way has the doctrine of subordination of everything to military efficiency been carried to the very beginning, and we are certain of efficient crews on board our ships because we have efficient recruits to begin with.

Iron Industry Gains in Germany.

DESPITE the smothering effects that the war has upon industry of all kinds, the production and manufacture of iron implements increased considerably in Germany since the opening of hostilities. During the last year of peace, 1913, the German iron industry mined approximately 35,941,000 tons of domestic iron ore, from which, after exporting 2,613,000 tons and importing 14,019,000 tons, a total of 19,300,000 tons of crude iron was smelted. During the month of August, 1914, when the war started, the output of iron products sank to 18,310 tons daily. During 1915 this daily average has increased to 33,000 tons. A large percentage of the iron being produced in Germany is finding its way into war implements of various sorts.

THE commission form of government is in effect in eighty-one of the two hundred and four cities in this country of over thirty thousand inhabitants.

Defending the United States with Motor Torpedo Boats

How deadly torpedoes can be safely carried on high-speed motor boats and how the landing of an enemy could be prevented by their means

By Edward F. Chandler

ON THE Atlantic coast alone there are no less than one hundred and sixteen undefended points where an enemy could land troops. New York, long considered invulnerable, is in reality helpless. Its guns are so mounted that an enemy fleet could lie off Far Rockaway and throw shells into Fourteenth Street. Not one of our guns could touch the invader.

Our own army officers have pointed out that 400,000 men could easily be landed on the Atlantic coast; that they could possess themselves of a line three hundred miles long, extending from Lake Erie to Chesapeake Bay; that they could hold that line at the rate of one man for every three yards or 176,000 for the entire length; and that the rest, 224,000 strong, could cut off ten of our states, all of our great manufacturing establishments, our munition plants, and our richest cities and financial institutions from the rest of the Union. In our harbor defences we have less than 15,000 men, who must remain where they are stationed to serve their guns.

Against this foreign invading force we could oppose no adequate resistance. The popular notion that we "can lick all creation" with pitchforks and shotguns finds no justification in our military history. In the War of 1812, Washington was defended by 5,400 raw recruits, mostly militia and volunteers. About 1,500 British soldiers ignominiously drove out the American defenders of the capital with a loss to themselves of only eight killed and eleven wounded.

Years must elapse before our coast defences and our mobile army can be developed into fighting units capable of frustrating an invasion of our seaboard states. In the meantime we must make the most of the civilian *matériel* at hand. And so we find that during the month of September the Navy taught a handful of motor-boat owners how to look for sub-

Each of the proposed motor torpedo-boat stations would be equipped with wireless sending and receiving instruments and would harbor from ten to fifteen boats

marines, how to locate mines, how to act as scouts and patrols, and how to perform, in general, the functions of a mosquito fleet. The Navy Department has gone even further. It has recommended the adoption of designs for power boats, which are to be so constructed that they can mount a gun in the bow in time of war and yet not interfere with their use as pleasure craft in time of war. These vessels can be employed only near shore for patrol duty.

Our thousands of miles of coast line can never be so perfectly protected by shore batteries that a landing by a hostile force is impossible. A powerful navy must always be relied upon to engage the fleet that is convoying a fleet of hostile transports. Since we are a fourth rate naval power it is not likely that our ships will be able to cope successfully with the superdreadnoughts and battle cruisers of any great European power. It would seem as if the transports would surely land their troops after the defeat of our small battle fleet. Coast defence submarines would naturally be used to thwart the attempt at landing troops. They must be mobilized for the purpose. At present our submarines are inferior to those of Germany or England, and we have not enough of them to defend thousands of miles of coast. What is more, a modern submarine costs $600,000.

Limitations of the Motor Boat

It is very evident that we need a weapon of defence which can be created almost overnight, as it were, which shall be at least as effective as a submarine, and which will appeal to the imagination and patriotism of coast dwellers. No doubt the motor boat meets the situation, and for that reason the efforts of the Navy Department to enlist the services of motor boat owners in the cause of national defence are commendable.

But the possibilities of the motor boat were hardly revealed in the recent maneuvers. Handled as they were last September they would have been powerless to prevent the landing of an enemy. Our Navy Department sees in the motor boat only a scout, a submarine antagonist, a mine detector, and not its larger possibilities.

There is no reason, to my mind, why the high-powered motor boat should not be employed to carry and discharge torpedoes. A torpedo, whether it is carried and discharged from a submarine, a torpedo-boat destroyer, or a motor boat will sink the largest battleship with equal effectiveness. But it must be carried safely and launched accurately. How this can be accomplished the accompanying illustrations of a motor boat of my own design reveal.

The torpedoes are attached to the hull, one along each side of the keel. Above: Diagram of the plan of the motor boat and end view showing the torpedoes suspended in position

Should an invasion of the United States be attempted the first troopship to appear on the horizon would be immediately attacked from all directions by the mosquito fleet

A modern torpedo is nineteen feet long and twenty-one inches in diameter, and it weighs over a ton. Obviously it cannot be carried on the deck of a small motor boat, or in an overboard tube. Accordingly I have devised a method of attaching torpedoes to the hull itself, one along each side of the keel. Thus supported the torpedoes neither add nor subtract from the weight of the vessel; for the torpedoes have neither positive nor negative buoyancy. There may be a slight reduction in speed; but that disadvantage is far outweighed by the formidable character of the weapon carried. No launching machinery is required; the mere starting of the torpedo-propeling machinery is enough for launching. The torpedo is so suspended that it can be dropped off, whatever may be the speed of the vessel. Still more important, the torpedoes are launched with the motor boat bow on, thus facilitating fire-control. The motor boat need only be pointed at its target; a torpedo launched from a deck-tube, athwartship, as on a torpedo-boat destroyer, may miss its mark because of a heavy roll. To be sure a motor boat will pitch; but pitching is never so marked as rolling and is more easily allowed for.

But is it not dangerous to carry torpedoes in this way? May not the motor boat be blown up by its own weapons? Rare experience convinces me that so long as the pistols in the warheads of the torpedoes are locked (and they will be unlocked only when the torpedo is to be fired) there is no danger. A warhead, even though it is filled with five hundred pounds of guncotton can withstand a severe shock.

At intervals of about one hundred miles along our coast stations would be maintained for ten or fifteen motor boats.

How the Motor Torpedo Boats Would Defend Us

Imagine, now, an attempt to invade the United States. Two hundred miles at sea our fleet is engaging the enemy's battleships in an effort to stop him from reaching our shores. The outcome of the battle is at least doubtful. Meanwhile his transports steam on. A motor scout sees them. At once the wireless telegraphic key of a radio operator flashes to the nearest boat station the number of the transports and their bearing. The news is wired from station to station. A veritable swarm of motor torpedo boats sets out. Their commander employs regulation torpedo-boat tactics; a dozen boats are sent against a single vessel; one at least will strike a telling blow. The boats lie low; they are difficult to hit. The enemy's transports, on the other hand, are large and very distinct. Moreover, the range is a mile and a half. The pistols in the war heads are set. A half dozen torpedoes are launched at once against the broadside of the transport. There is the thunder of an explosion; a troopship dives head foremost into the waves; three regiments perish.

Introducing Our First Anti-Aircraft Gun

Photo Central News

Mounted on a special platform forty feet high on the battleship Texas is a three-inch naval gun adjusted so that a high angle of elevation can be attained. It is said to be the forerunner of a new type of anti-aircraft gun with which those most interested in our naval and military "preparedness" will adorn the first-line battleships of the future

America's First Thirty-Five Knot Battle-Cruiser

COMMON sense teaches everyone that speed, range, striking power and adequate armor protection, are essential in a fighting vessel and the ship in which these are combined to a pre-eminent degree most fully meets the ideal. But it is no easy matter to unite all these attributes in a single craft of a given tonnage. If a battleship is excessively armored, weight must be saved elsewhere—in guns, engines, etc. And so it happens that every fighting ship is more or less a compromise effected by the advocate of speed with the advocate of heavy guns and thick armor.

Although the developments in battleship construction have been exceedingly rapid, the greatest impetus was given about ten years ago when Great Britain came to the fore with the Dreadnought, a ship which mounted only big guns, namely ten twelve-inch rifles. She was fast too, for her speed was twenty-one and one-half knots, something unprecedented in battleships.

Soon the superdreadnought appeared, a vessel still faster, mounting still bigger guns, and still more heavily armored. Then came the battle cruiser, a formidable craft with a speed of twenty-eight knots—a type also first introduced by Great Britain.

These battle cruisers—vessels which mount somewhat fewer heavy guns than the superdreadnought, but of the same caliber, and which have somewhat lighter armor and the greatest speed that can be given to a warship are at last to be introduced in our own navy. If we were to engage now in a naval war with a foreign power, we would be hopelessly at a disadvantage, not only because of the fewness of our superdreadnoughts, but because we utterly lack battle cruisers.

While no official announcement has been made of the principal features of these new ships, the POPULAR SCIENCE MONTHLY is in a position to present details which may be accepted as accurate.

Profiting by the lessons taught by the engagements fought off the Falkland Islands and in the North Sea, this new battle cruiser of ours is to have a speed somewhere between thirty-two and thirty-five knots. Obviously engines of enormous power are required to attain that speed, and so we may expect that one hundred thousand horsepower must be generated. Every additional knot means an inordinate increase in engine capacity.

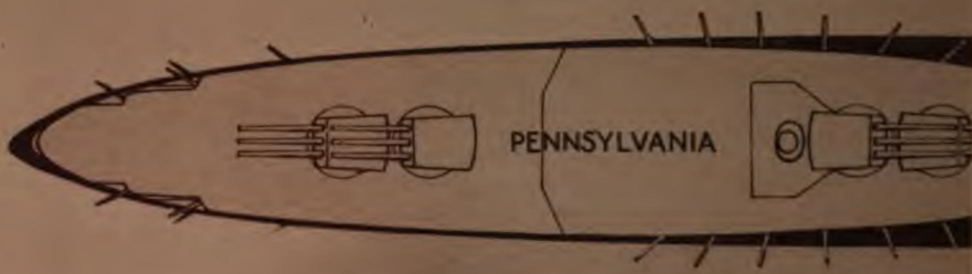
Our unbuilt and unnamed battle cruiser will have eight fourteen-inch guns and twenty five-inch guns. At first blush it would seem as if the *Queen Elizabeth's* fifteen-inch guns must carry the day if these two ships were ever opposed. But our ordnance officers have made the statement that the new fourteen-inch guns which they have developed are the superior of the fifteen-inch guns at present used in the British navy—or statements to that effect.

The armor protection of the new United States battle cruiser is to be twelve inches amidships and four inches at the ends. The *Queen Elizabeth* has thirteen and one-half inches of steel on the waterline, ten inches above that and a top layer of eight and one-quarter inches. It is here probably that we had to make our sacrifice in order to gain the engine power and, therefore, speed. But if speed will enable our ship to pick out her own position and our guns have the greater range, the loss in armor protection is more than compensated for.

The *Lion* and *Tiger* are battle cruisers in the true sense of the word. Our ship will easily outdistance them. In tonnage there is not much to choose, for they displace thirty thousand tons as against the thirty-one thousand tons of our vessel. In armament we will be far superior. The *Lion* and the *Tiger* each mount eight fourteen-inch guns which are probably inferior in range to the guns of equivalent caliber on the proposed American ship. The *Tiger* has twelve six-inch guns and the *Lion* sixteen four-inch guns; but weapons of such small character play no part in a long range engagement and are serviceable chiefly for the repulsion of torpedo boats.

The First Battle Cruiser of the United States Navy—a 35-knot Fighting Ship

Length, overall, 730 feet; beam, 88 feet; maximum draft, 30 feet; displacement, about 31,000 tons; horsepower, 100,000; speed, 32-35 knots; armor, amidships 12 inches, ends 4 inches; main battery eight 14-inch rifles, secondary battery twenty 5-inch rifles; drive, turbine-electric



> "Is it not fair to assume, nay, is it not certain, that if battleship displacement has increased from ten thousand tons in 1896 to thirty-two thousand tons in 1916, that it will continue to do so until the limit has been reached? Why not go the limit at once? By so doing we scrap the battleships of every navy in the world. . . ."

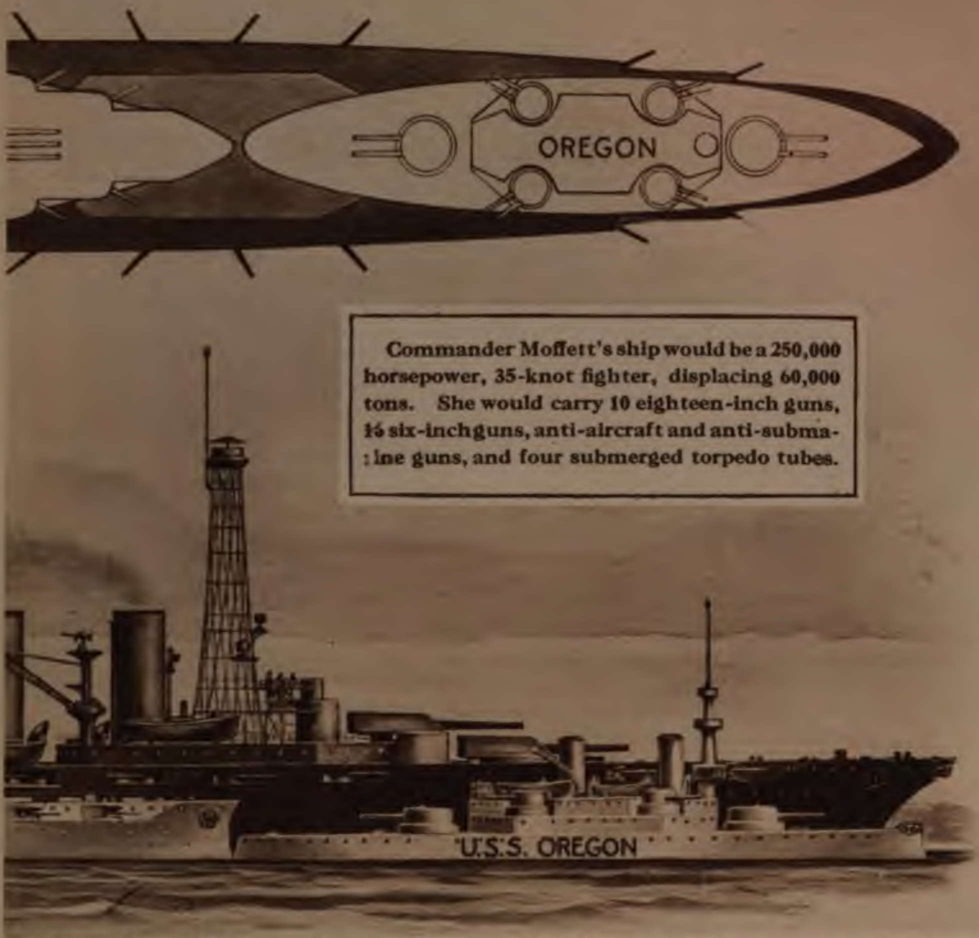
Moffett's ship, shown behind the Pennsylvania and Oregon, is about as long as both vessels.

The Thousand-Foot Battleship

Commander Moffett's daring plan to beat the world

HITTING a target at ten miles with fifteen-inch guns seems so easy a task in view of the naval battles fought off the Dogger Bank and Jutland that Admiral Sir Cyprian Bridge of the British Navy, maintains that it is inadvisable to build warships bigger than those now in commission. Commander William Adger Moffett of our own Navy, takes direct issue with him, arguing that the whole tendency in warship construction from the days of the sailing frigate to the modern super-dreadnought has been toward the large ship with large guns. He boldly advocates a vessel more than twice as large as any battleship hitherto constructed—a veritable Titan of the seas.

In an article published in "Sea Power," Commander Moffett points out that only the size of the locks of the Panama Canal limits the size of battleships. That limit applies to the warships of the entire world as well; for no power would sacrifice the advantage of being able to send its fleet through the Canal. Since the Panama Canal locks will receive vessels of one thousand feet length and



Commander Moffett's ship would be a 250,000 horsepower, 35-knot fighter, displacing 60,000 tons. She would carry 10 eighteen-inch guns, 16 six-inch guns, anti-aircraft and anti-submarine guns, and four submerged torpedo tubes.

She could carry the Pennsylvania and Oregon on her decks, as illustrated in the top plans

one hundred and ten feet beam, the maximum length and beam of the future warship are fixed. "Go the limit at once," urges Commander Moffett, "while we have the opportunity to do it, ahead of all our rivals, and go the limit at the same time in everything; that is to say, in speed, caliber of guns, endurance, fuel, ammunition, etc."

Puts Limit at 60,000 *Tons*

Commander Moffett points out that the growth of the United States battleship from the Oregon type to the new Pennsylvania has been accomplished in less than twenty years, and submits in addition the specifications of his proposed sea giant, the Limit, in the following comparative table:

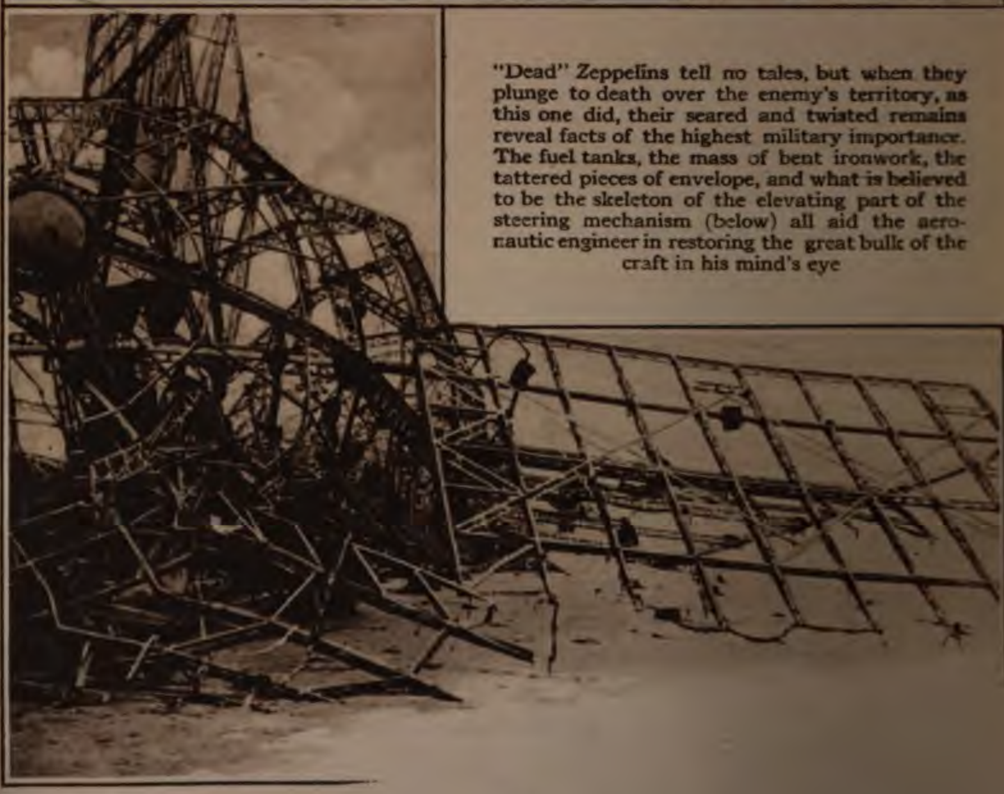
Battleship	Date	Length	Arm'm't.	Ton'ge
Oregon........	1896	358 ft.	4 13-in.	10,288
So. Carolina...	1909	450 ft.	8 12-in.	16,000
Delaware......	1910	510 ft.	10 12-in.	20,000
Pennsylvania..	1915	600 ft.	12 14-in.	31,400
Limit.........	1917	995 ft.	15 18-in.	60,000

To quote Commander Moffett:

"Other navies would have to follow our example, and build ships like ours or give up the competition. We could stand the cost better than any other nation. It is, therefore, an advantage to us to make navies cost as much as possible. We have more money than any other nation and will have more, comparatively, at the close of the war, when most of them will be bankrupt.

"In this way we will scrap England's navy, as well as all others. In no other way can we hope to overtake Great Britain.

"Build the limit in displacement, in speed in caliber of guns, with proper proportion of fuel and ammunition, endurance, etc., and we will have, indeed, the first real superdreadnought."



"Dead" Zeppelins tell no tales, but when they plunge to death over the enemy's territory, as this one did, their seared and twisted remains reveal facts of the highest military importance. The fuel tanks, the mass of bent ironwork, the tattered pieces of envelope, and what is believed to be the skeleton of the elevating part of the steering mechanism (below) all aid the aeronautic engineer in restoring the great bulk of the craft in his mind's eye

Decoy Targets for Zeppelins

By R. J. Bjierstedt

THERE is no doubt that more powerful guns are now available than those which made so ridiculous a showing during the September and October raids on London, but the problem of adequate range finding is so nearly prohibitive that few who are familiar with it pin much hope to a gun defense.

I am credibly informed, however, that what might be called "diversionary" protective measures have been employed with considerable success. These consist of various ingenious devices calculated to draw the fire of the Zeppelins away from the points where they could do the most harm. So far, these appear to have been employed principally in the important manufacturing districts between London and the North Sea rather than in the immediate environs of the metropolis. The idea is said to have originated in the mind of a Norfolk farmer after a pile of chaff which he had been burning on the night of a raid was made the target of several well-placed Zeppelin bombs.

"The Zepps thought my fire was the blast of the —— mills," he told an air service officer. "Why not have some ready to fool 'em the next time they come?"

Since factories and barracks were the main objects of attack, why not provide some that could be found without difficulty and the destruction of which would be of small moment. The first experiment was made by cutting "window-holes" in a row of bill-boards—"hoardings" the English call them—along a railway, and illuminating each orifice with a carbide lamp. When these came in for attention from the raiders, the present plan of using "stage scenery" factories and barracks as Zeppelin decoys was outlined.

These decoys consist simply of sections of imitation walls, pierced with windows, which, by means of guys and props, can be made to represent the side or sky-lighted roofs of a factory or barracks. Where practicable the illumination is furnished by running a cable from the nearest electric transmission line, and where this is too troublesome or expensive, carbide or kerosene lamps are employed. The sections hook or clamp together and are made small enough to allow of a stack of them being carried on one of the big war motor trucks.

An interesting light is thrown on this phase of protective work by a photograph that was published in England about three months ago, and probably also in the United States. It showed a huge war motor truck, with an enormous tarpaulin-covered load, stalled between the copings of an old stone bridge over which it had endeavored to pass. The caption merely explained that it was "Somewhere in England," and that the load itself was an "official secret." Most of the information which I have set down above came to me as a consequence of this photograph.

I chanced to be looking over the copy of the *Daily Mirror* on the cover of which the view in question appeared, when a garrulous and slightly inebriated "Tommy" who shared my third class apartment with me asked if I knew what the load was.

"Not beyond the fact that it is an 'official secret,' I replied. "Do you know anything about it?"

"Blime me if I don't," was the answer. "She wuz carryin' stage scen'ry; stage scen'ry fer the Zepps."

The man, it appeared, was a member of the Army Service Corps, and was just returning from the hospital where to use his own words, he had been to "git a hunk o' 'fact'ry' " picked out of him.

His injuries, he said, had been received when a "factory" which he had helped to erect was actually struck and demolished by a Zeppelin bomb. They had just switched the lights on from their dug-out, he said, when the Zeppelin hove in sight and headed up to pass right over the decoy. The "factory" was blown to pieces, but a couple of hours' repair work on the morrow left the shattered sections in as good shape as ever.

Decoys for Zeppelins

In order to deceive bomb-dropping Zeppelins, the English are building "stage" factories (mere painted scenes) which are illuminated at night

Refinements in War Motors

Motor-trucks equipped with searchlights have played an important rôle in the World War. They have multiplied in number until now hundreds are employed by each of the warring nations. Above is shown a high-power searchlight illuminating a road. The truck is of American design and manufacture

An American manufacturer has designed a truck operated from both ends. When beset by the enemy the crew need not turn around. The car fitted with an armor body is shown above at the left, while the stripped chassis may be seen below, the superstructure being drawn in faintly to show the positions of the drivers

The German spiked helmet of gleaming nickel was hidden, early in the war, with a gray cloth cover. Now the spike has disappeared, though the helmet itself is still of metal and still carries its cloth cover. The picture on the left shows the newest German officers' uniform, free from almost every distinguishing sign that would make the officers a special target for the enemies' sharpshooters

The British have adopted the steel helmet of construction similar to that of the French. It is now in general use and is shown to the right. Below are shown the new German uniforms for the Russian winter campaign, consisting of caps and overcoats of white slipped over the regular uniforms, making the wearers almost invisible against the snow over which they are now engaged in fighting

The French Helmet's Practical Success

The new field equipment of the French infantryman. The French have gone far in their efforts to substitute for their comic-opera uniforms of blue and red a practical fighting costume, and they may now be considered as well clothed as any soldiers in the field. The steel helmet is the latest addition, and met with instant favor among the fighting men. The helmet is admirably designed, and tends to prevent the multitude of head injuries which have swelled the mortality rate. The illustrations of damaged helmets show the remarkable strength of this head-gear, for in all cases shown, the soldier was only slightly wounded by missiles which would otherwise have killed him

Secret Gasoline Supplies for Submarines

A submarine at sea can replenish its supply of gasoline or oil by means of the device illustrated. Within an outer container, a tank of gasoline or oil is placed. Between the outer container and the gasoline tank is a space filled with water. When the water is forced out by compressed air, container and tank rise to the surface

A float hidden in seaweed conceals the means of raising the tank to the surface. After the tank has been brought to the surface the submarine proceeds to replenish its supply of fuel by the simple expedient of pumping it into its reservoirs

Making the Deadly Trench Torpedoes

The caps which cover the ends of the torpedoes of large caliber are heated at the forge as shown above, and then welded to the body of the projectile

A completed trench torpedo and its parts before assembling

When they are finished, the projectiles are carefully tested with delicate instruments to verify the sizes and alinements. These clumsy looking bombs are thrown with amazing accuracy

From the World's Greatest Battle-Ground

At the scene of the world's greatest battle. Dummy-trench mortars behind the French lines at Verdun

A queer result of a high-explosive shell is shown to the right. In a French church a statue was struck by a shell. The statue was broken into fragments, but the head was hurled against the wall with such force that it was embedded in the masonry

In the great battle of Verdun, ammunition was fired in almost inconceivable quantities. Hundreds of motor-trucks, similar to those shown above dashed continually between the lines and the base of supplies, constantly replenishing ammunition and victuals